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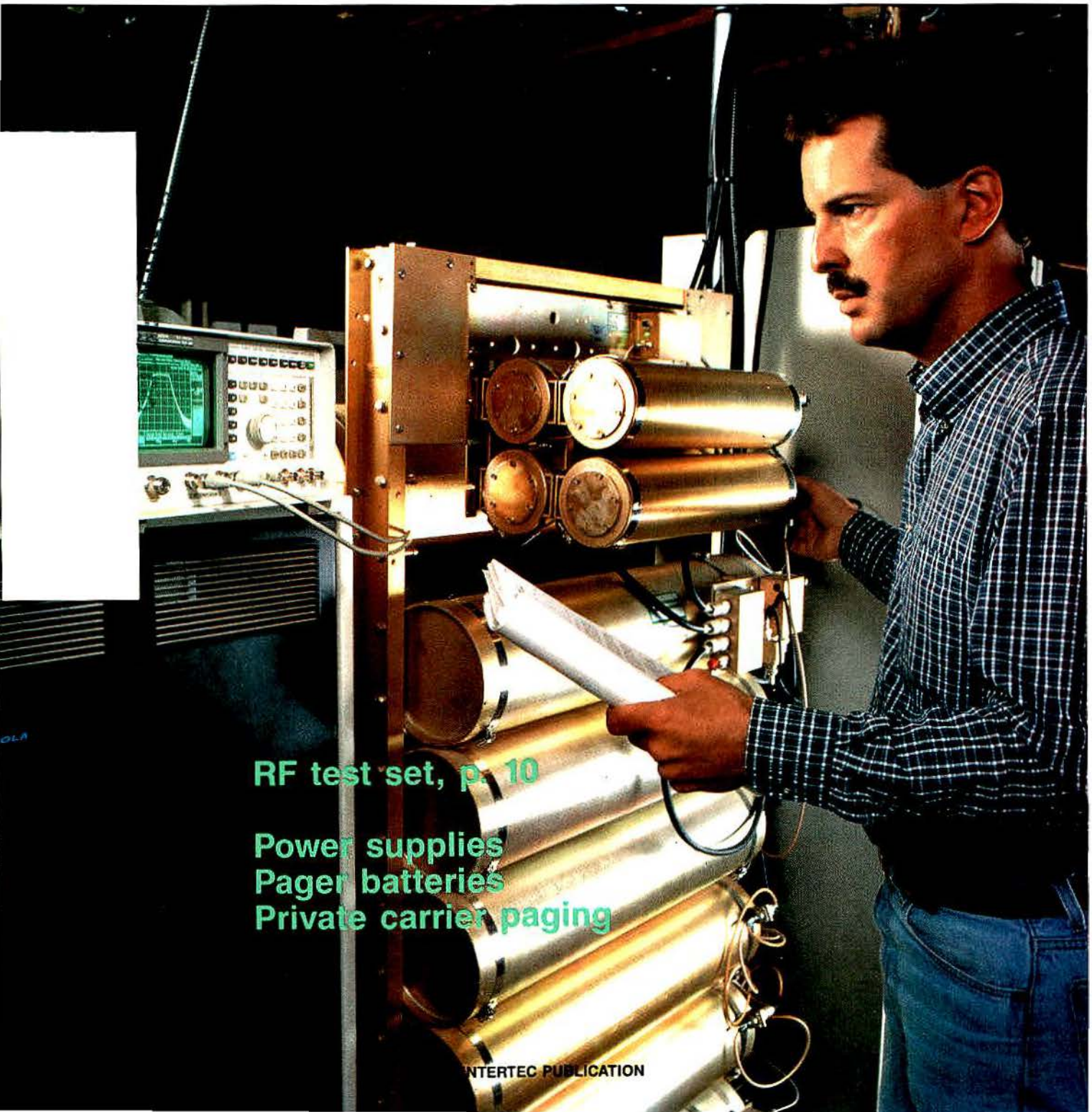
Mobile Radio Technology

The journal of mobile communications technology



RF test set, p. 10

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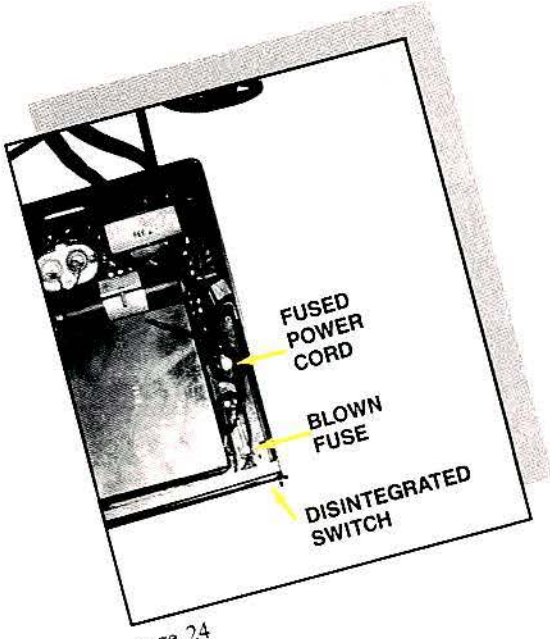

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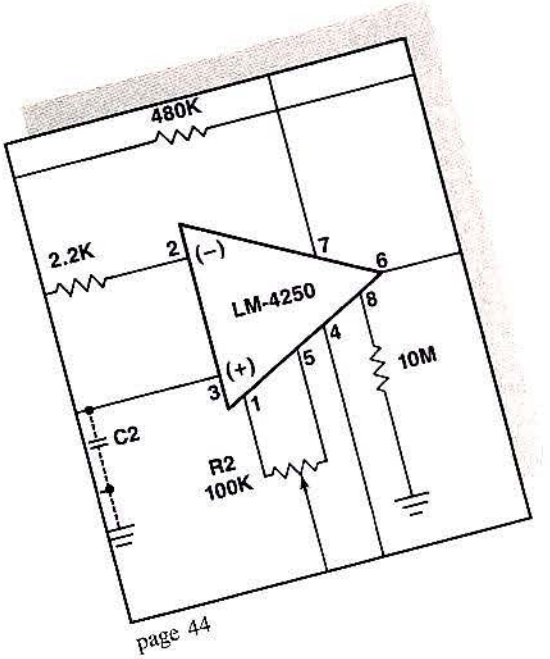

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Raymond C. Trott, P.E.
Everyone wanted 152.480MHz when it was the VHF frequency with the highest power. Now that the power limit has been raised for 157.740MHz, its popularity will rise. But lower-power alternatives may be far better.

On the cover: An RF communications test set is used to adjust cavities at a radio communications equipment site. See John Richardson's article on page 10.

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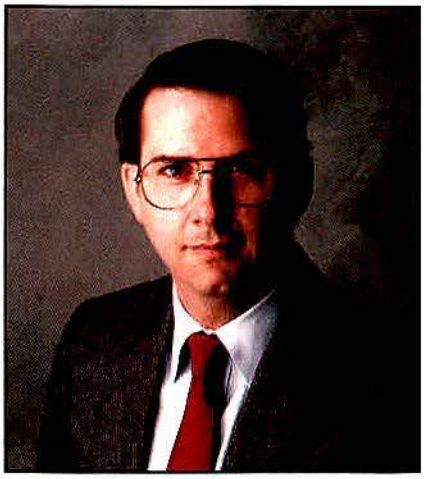
Editorial

Amateur ratio spectrum deserves federal protection



Congress has before it a bill introduced by Rep. Jim Cooper (D-TN) that would prevent further loss of radio spectrum now allocated to the Amateur Radio Service. The bill should be passed.

Radio spectrum is a natural resource that undergoes development by commercial enterprises, governmental agencies and the armed forces.

Personal spectrum use

Individuals make personal use of radio spectrum in the United States via what the FCC calls the personal radio services, the Amateur Radio Service, the General Mobile Radio Service and the Citizens Band Radio Service. Almost any other personal use of radio spectrum requires paying someone for service, such as a specialized mobile radio (SMR) system operator or a cellular mobile telephone system operator.

The profit to be made by developing radio spectrum and selling access to it drives a commercial engine that delivers products, services and jobs. Commercial spectrum development supports industrial productivity and America's ability to compete worldwide. The benefits of commercial radio spectrum development cannot be denied.

Personal access to radio spectrum through the Amateur Radio Service delivers benefits, too. Emergency communications services provided by radio amateurs improve public safety, protect property and save lives. Radio amateurs have an admirable record of providing emergency communications services in connection with floods, tornadoes, forest fires, earthquakes, blizzards, train wrecks, chemical spills and other disasters.

Personal access to radio spectrum leads individuals into careers where they can pioneer and sustain developments to keep the United States a world leader in telecommunications. The value of the Amateur Radio Service in attracting bright young minds to telecommunications is incalculable. It would be easy to recite the names of telecommunications pioneers whose lifetime pursuits were shaped by early involvement in amateur radio.

Personal access to radio spectrum offers recreational opportunities, too. In that respect and in several others, radio spectrum resembles real estate. Location, quantity and use determine its value.

Spectrum conservation

Congress has seen fit to conserve real estate for personal recreational use in a system of national parks, monuments and historic sites. It should do the same for radio spectrum.

Although commercial development of real estate brings myriad benefits, commercial development of *all* U.S. real estate would change the beauty and appeal of public lands. It would deny many individuals access to recreational opportunities now available through protected parks, forests and seashores. Congressional protection of national parks seems strong enough to withstand requests for commercial development.

Radio spectrum devoted for personal use needs similar congressional protection. Beginning in the early 1900s, personal access to radio spectrum through the Amateur Radio Service has had to be defended time and time again. Since 1934, most spectrum reallocation requests have been decided by the FCC. Increasingly, the FCC has chipped away at personal access to radio spectrum in favor of commercial development.

The Amateur Radio Spectrum Protection Act of 1991, which Rep. Cooper introduced as H.R. 73, would ensure that individuals who make personal use of radio spectrum through the Amateur Radio Service can continue to use all of the frequencies they now use. If the FCC proposes to reallocate the spectrum for other purposes, the bill would require that amateur frequencies lost in the process be replaced by equivalent spectrum.

A letter to your congressional representative can help to protect personal use of radio spectrum via Amateur Radio Service allocations. The bill deserves your support, and amateur radio spectrum deserves federal protection.

* * *

Fleet Call

The nation's second-largest specialized mobile radio (SMR) licensee, Fleet Call, asked the FCC to waive certain rules to allow the construction of low-power, multisite digital radio communications facilities on its channels in six of the largest U.S. markets.

The request won support from much of the SMR community, though some operators are guarded in their response and some oppose the plan. The cellular telephone industry virtually is united in its opposition.

What would the FCC do? Among the possible answers were:

(a) Turn down the waiver request and thus prevent Fleet Call from moving forward with its plan.

(b) Grant the waiver request.

(c) Initiate a rulemaking proceeding that might result in a change in its rules to accommodate the Fleet Call plan.

The correct answer is:

(d) The FCC turned down most of the waiver request and said Fleet Call may construct its system, virtually as proposed, under present rules. The agency granted Fleet Call a waiver for a five-year construction period.

The FCC action, which is almost a non-action, has a delicious element of surprise. For example, it almost completely defuses the opposition. Waiver grants and rulemaking proceedings can be protested, delayed and perhaps defeated. It is much more difficult to block an endeavor permitted under current rules.

With Fleet Call in the lead, the SMR industry is about to take a giant step toward increased capacity and spectrum efficiency.

—Don Bishop

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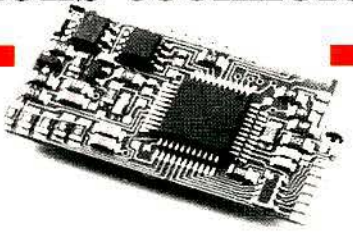

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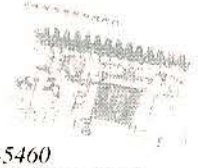

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Letters to the editor

Bulletin board services:

I work as an electronics technician at a government hydroelectric power facility. The range of my maintenance and installation duties include highband and UHF mobile radio; microwave radio; telephones; remote terminal units; telemetry; computers, metering and relaying.

I rely on your magazine for pointers and new information to assist me in my work and quite often I use it for purchasing information.

I really appreciate articles that get down to basics with common-sense maintenance tips and step-by-step alignment procedures. In a wide-ranging job such as mine, that kind of article is really useful.

How about a listing of computer bulletin board services where mobile radio technicians can compare notes and obtain advice from their peers? Are there such services available?

James Creitz
Yellowtail Dam
Hardin, MT

Readers, do you have information about the type of services James Creitz seeks? —*DB*

Privacy Act:

I am writing in response to Richard Massie's letter in the November issue. I fully agree with *MRT's* opposition to the 1987 Electronic Communications Privacy Act as it applies to cellular communications in particular.

When Improved Mobile Telephone Service (IMTS) was in its heyday, no one seemed to object to the ability of scanners to monitor telephone calls. In fact, some scanner manufacturers provided features to scan over the IMTS idle tone so it would not "lock up" the scanner.

Along came the cellular people who have thoroughly lulled their customers into believing that they will enjoy the same privacy as a user of the public switched network.

But on that score, let's be realistic. For example, my state, New Jersey, frequently has led the nation in the number of court-ordered wiretaps. People who are in prison because of convictions supported by evidence gleaned from wiretaps know that the public switched network is far from private.

By way of anecdote, when the first cell site was turned on in my area, I happened to tune across several cellular calls with a service monitor. The nature of some of these calls was that of selling illegal drugs, as well as gambling.

In the "old days," people who used ship-to-shore or IMTS telephones had enough sense to know that they were talking over a radio. They adjusted their conversation accordingly.

No matter what, a radio is a radio—

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The journal of mobile communications technology

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plain and simple. Let the cellular user (or *any* radio communicator, for that matter) beware of his potential lack of privacy. Perhaps it should be the burden of cellular phone manufacturers to put warning labels on their equipment and not on scanner and other types of receivers.

H. Robert Schroeder
Trenton, NJ

From Fast Fact Cards:

The two toughest problems on the job include:

- communication between officers.
- being as courteous as possible to everybody we meet.

Ronald Durant
Chief
Heritage Security
Tustin, MI

The most difficult problem on the job is explaining to new two-way radio customers why they should pay for frequency coordination when we already know what frequency to apply for.

H. Renshaw
World Audio Service
Gary, IN

Unlicensed operation:

I read your editorial in the February issue and have a couple of comments.

For the most part, you are correct in most all areas as to the problems caused by unlicensed users. These are very serious problems and, if not stopped and corrected, they will turn this industry into the same garbage pit that citizens band radio has become.

We have been in business 36 years, and we have seen it all. The problem of unlicensed users comes primarily from two causes:

(1) The big distributors, discount houses and mass-marketers advertise and sell to anyone. These people peddling Radius (as they all are), JobComm, Tekk or whatever ship anywhere (no questions asked) as long as you send them the money. No license required! They sell at discounts that the small dealers cannot, and they have no scruples. The honest dealers are getting tired of being undersold, and no license ever is discussed!

(2) Even more insidious to honest dealers, we break our butts, spend hours and hours to get a system together and even possibly win a bid, and then spend more hours in getting a license application filled out properly. We send it off to the *monopoly* coordinators, and you had best be prepared for real problems. These people grab your money up front and have no further desire to help you with a conflict, delays or whatever.

We have, as do most all reputable shops, real war stories on delays of up to *six months*, outright loss of applications or whatever. These problems with the coordinators are real, as well as being five times too expensive.

I agree, a good swift kick in the —, as well as the pocketbook, is in order. But let's kick the right ones.

R.E. Hafla
Teton Communications
Idaho Falls, ID

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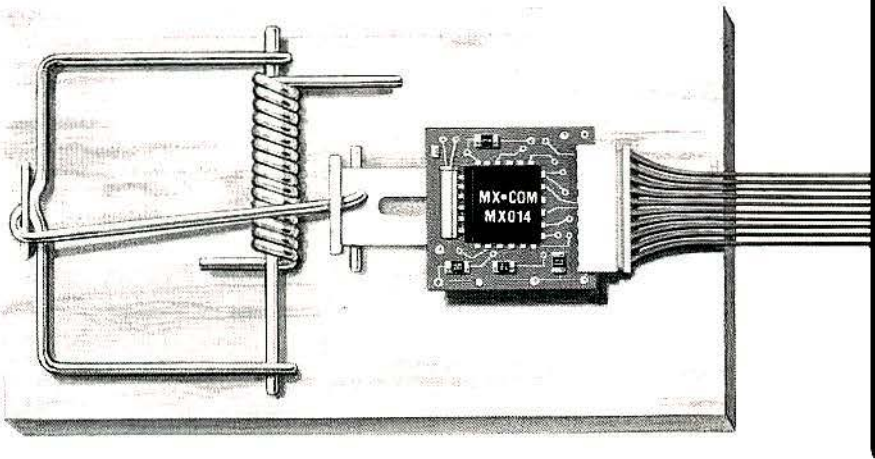

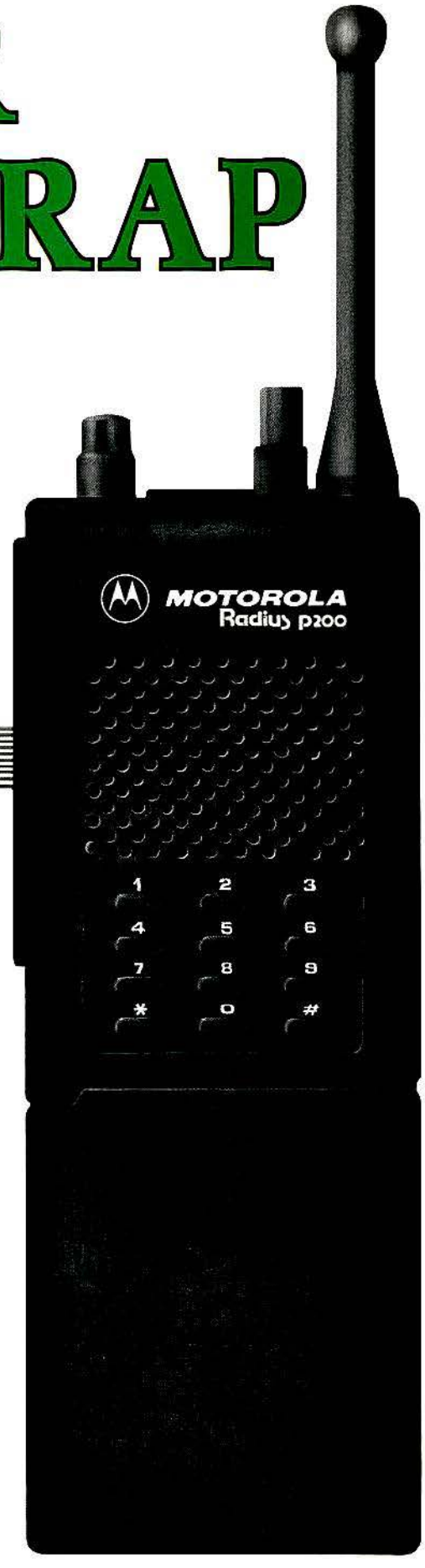

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RF communication test set speeds radio repair

Sophisticated automatic test routines from the manufacturer or written by the user boost the speed and reliability of radio equipment maintenance and repair with a test set made for service shop and field use.

By John Richardson

Feedback from test equipment users and research into the special needs of radio service shops led to the development of a new RF communication test set. The set is not just a tool box of RF functions, but goes a step further to help technicians reach a higher level of quality in radio repair and to complete the work more quickly.

To deliver these results, the set is designed to:

- perform more complete radio tests with less effort.
- provide more reliable test results.
- deliver a broader range of test capability in a smaller package.

Complete radio tests

Technicians usually perform similar or identical tests on radios before and after repairing them, prior to returning them to customers.

Using test routines stored in a plug-in card with read-only memory that directs a microprocessor controller, the test set "powers up" ready to test common land mobile radios quickly with less effort than before.

Richardson is the marketing project manager for the HP 8920A RF Communication Test Set at Hewlett-Packard, Spokane, WA. The test set is described in this article.

Left: A technician uses the communications test set to tune cavities at a radio transmitter site.

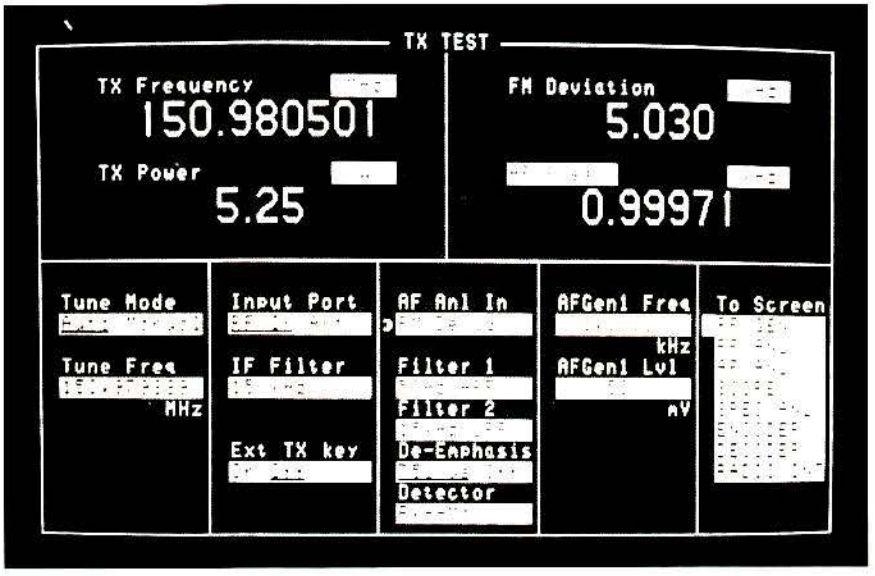


Photo 1. To help with adjustments that 'tweak' the radio's performance, the test set displays audio frequency, distortion, dc level and current drain.

• *Transmitter testing*—Common transmitter tests are conducted as follows:

(1) Connect the transmitter output to the test set's RF input.

(2) Press the "TX" key on the test set, and key the transmitter.

The test set automatically tunes to the transmitter frequency and measures frequency and power. A frequency counter and a microprocessor find and tune to a transmitter carrier in less than one second, typically. The screen displays deviation and audio frequency measurements simultaneously when you whistle into the microphone.

The "whistle test" quickly verifies functioning modulation. To accurately measure transmitter deviation, use the test set's internal audio source to modulate the transmitter with a known and specific audio level and frequency.

The screen displays radio frequency, power, deviation and audio frequency test results simultaneously. The radio frequency, or the set can display an "error" figure from a known channel frequency or it can display the absolute radio frequency.

The radio's distortion, dc level, current drain, or SINAD may be measured and displayed instead of audio frequency.

To help with adjustments that "tweak" the radio's performance, the test set can display audio frequency, distortion, dc level and current drain. The screen displays transmit and receive functions with either analog bar graphs or digital readouts. (See Photo 1 above.)

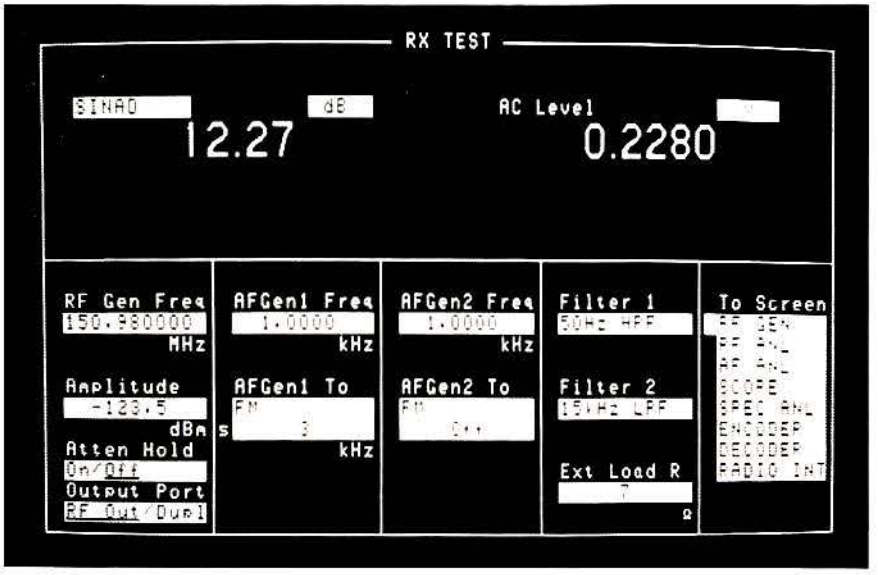


Photo 2. The test set measures SINAD, distortion or audio frequency and displays ac voltage (audio power) simultaneously with any one of the other three measurements. The simultaneous display of either analog bar graphs or digital readouts helps to give you more usable information in one place.

• *Receiver testing*—Common receiver tests are conducted as follows:

(1) Connect the receiver's accessory speaker output to the test set's audio input.

(2) Press the test set's "RX" key.

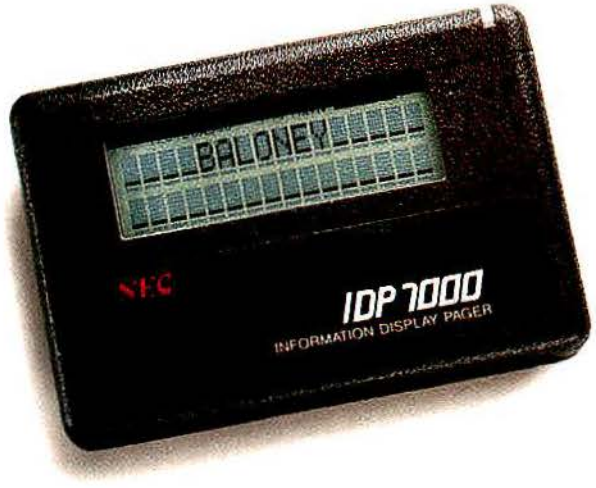
(3) The test set measures SINAD, distortion or audio frequency. It measures ac voltage (audio power) simultaneously with any one of the first three measurements. The simultaneous display helps to give you more usable information in one place. (See Photo 2 at the left.)

To measure SINAD, tune the test set's generator to the receiver's input frequency, set 3kHz deviation and 1kHz audio tone. The test set automatically displays SINAD. Adjust the generator's output level to give 12dB SINAD. Distortion is measured with the same procedure.

To measure audio frequency, the test set's RF generator generates received audio, which then is detected by the receiver under test and presented to the receiver's speaker terminal.

These characteristics, SINAD, distortion and audio frequency, can be measured automatically with optional software. Using the software, the operator responds to prompts from the test set to control the receiver under test.

A SHORT MESSAGE FOR THOSE WHO THINK ALPHANUMERIC PAGERS HAVE TO BE COMPLICATED.



It doesn't get any easier than the NEC IDP 7000 alphanumeric pager. One button, one touch operation controls most of its functions. And while it's simple to use, the data it provides is anything but.

More than numbers and names, it provides complex information like stock quotes, directions, memos—even weather alerts.

Specific messages of up to 32 characters are easily read on a recessed screen that's twice as large as its nearest competitor.

The IDP 7000 is also easy to sell and service. It even has a unique remote control capability that allows you to suspend and resume service.

Standard bells and whistles include a large 7000 character memory, a battery backup, automatic display illumination, an available memory indicator and alert modes.

For your customers who want sophistication without complications, the IDP 7000 is an easy sell.

And that's no baloney.

NEC

C&C Computers and Communications

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Usually, the receiver only needs to be connected with the test set's audio output (speaker) and RF input (antenna) connections and switched on. In some cases, manual controls may need to be set.

• *Duplex radio testing*—Tests for radios that are built to transmit and receive simultaneously (duplex operation) are conducted as follows:

(1) Connect the radio to the test set as follows:

- Radio "antenna" to test set "RF In/Out."
- "Mic input" to test set "audio out."
- "Speaker terminal" to test set "audio in."
- (Optional) "power supply lead" to test set "dc current input."

(2) Enter the radio's transmit and receive frequencies.

(3) Key the transmitter.

The test set displays transmitter frequency or frequency error and RF power output. The frequency error is the difference in kilohertz between a channel frequency the operator enters and the actual frequency of the transmitter under test.

If the operator uses transceiver-testing software to test the radio, he can enter many channel frequencies. Then, the test set can step through each channel and measure frequency error for each one. The software prompts the operator to change channels as it steps through the preset channels.

Distortion and dc level can be measured from the detected modulation from a transmitter...

(4) Unkey the transmitter.

The test set can display two readings simultaneously, ac level and one of the following: SINAD, distortion, ac frequency, dc level or current. Offsets as great as 1,000MHz can be accommodated.

The test set measures audio distortion by feeding a 1kHz audio tone into the mic input. Then, the set demodulates the RF carrier and measures distortion.

It measures receiver distortion from the speaker output.

The test set measures the dc level of any incoming signal at 10 points within the instrument. The most useful points at which to measure dc level include the audio input port and the external modulation output.

To measure distortion and dc level, the operator connects the test set's audio input to the receiver's audio output, typically a speaker lead. Distortion and dc level can be measured on the detected modulation from a transmitter, too.

Dc current is measured with the dc supply lead connected to one connector on the test set's rear panel and the transceiver power supply unit lead connected to a second connector. A Hall-effect transducer measures current flow

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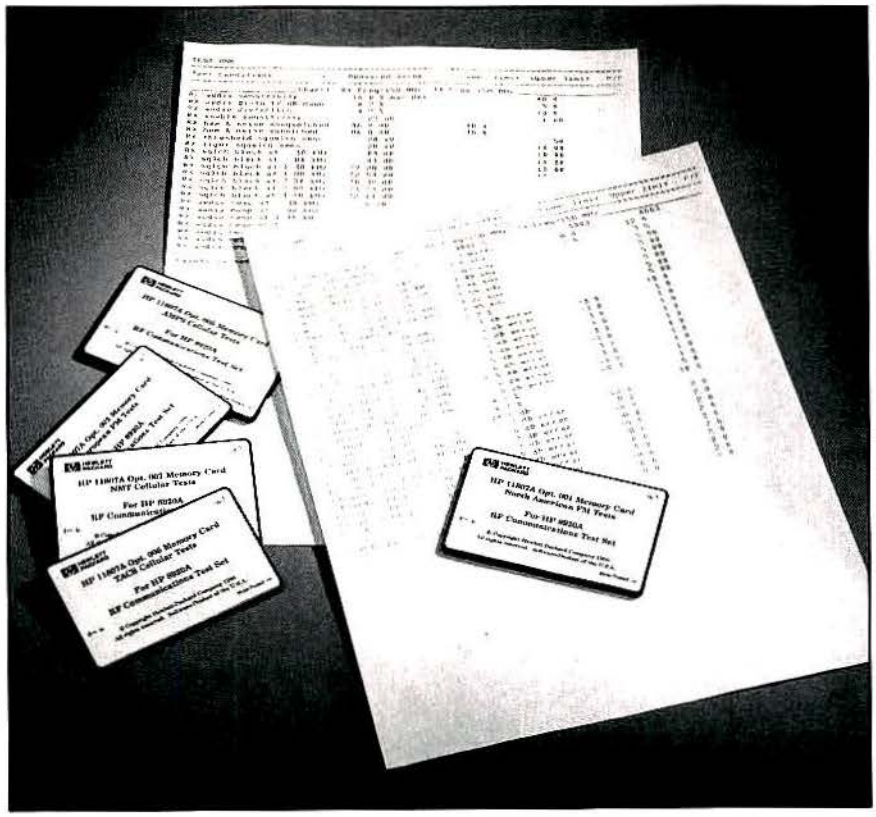

through the second connector.

• *Automation*—When a shop maintains a large quantity of one or two types of radios, maintenance quality and repair speed can be boosted through automatic test routines. The test set's built-in computer uses available software or Basic language programs you can write to carry out automatic testing.

I-Basic programs can be entered as an American Standard Code for Information Interchange (ASCII) file via HP-IB or RS-232 connections from any personal computer with input-output capability.

A programming manual is available to help you write I-Basic programs. Once written, programs can be stored on memory cards. (See Photo 3 at the left.) The cards are available in 32K

Photo 3. A programming manual is available to help you write I-Basic programs. Once written, programs can be stored on memory cards such as the one shown. Cards are available in 32K byte, 128K byte, 256K byte and 512K byte sizes to store programs from small-to-large size.

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Astron Corporation is the leading manufacturer of high-quality power supplies and converters for the land mobile industry.

With the new SL-11 series of low profile power supplies, specifically designed for base station applications, the setup is simple, easy and looks attractive. Just mount the radio, with the mounting pads (supplied with the power supply), to the top of the SL-11A (2¾"H x 7⅝"W x 9¾"D) or the SL-11R (2¾"H x 7"W x 9¾"D). The power supplies are very well regulated and will provide 11 amps of current at a 50% duty cycle. The units have fold-back current limiting to protect them from overload and short circuit, and an overvoltage protection feature to protect the radio should the output voltage exceed a safe level. All SL series units are available in dark gray or black.

Power supplies and converters from Astron: our unsurpassed quality and reliability have made us the #1 choice in the communications industry.

SL-11R (black)

SL-11R (dark gray)

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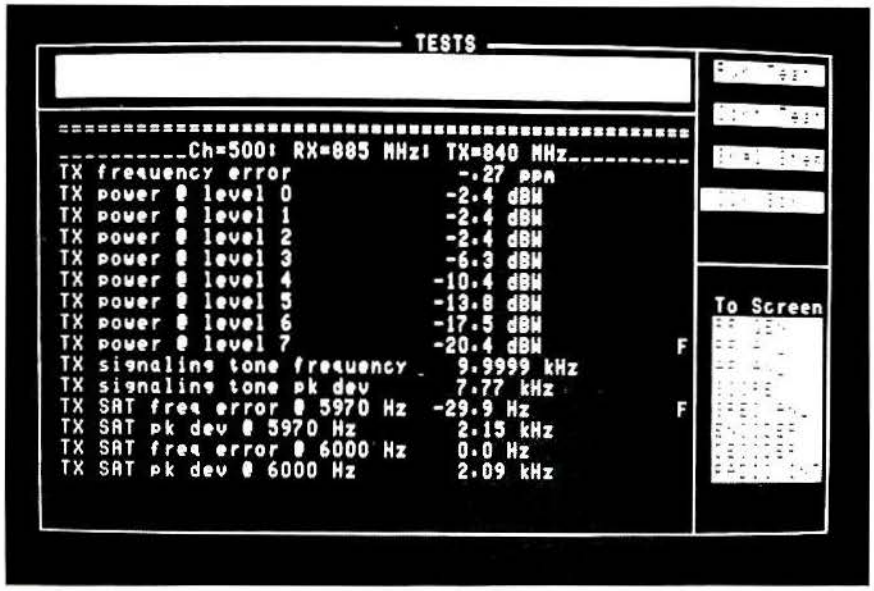

Photo 4. As the set performs tests, it displays a pass-fail indication next to each result, as shown by the letter 'F' in the righthand column of the display.

byte, 128K byte, 256K byte and 512K byte sizes to store programs from small-to-large size.

HP 11807A radio test software enables fully automated testing. The software comes on memory cards for testing AM, FM, PM (phase modulation) radios and cellular telephones. It supports EAMPS, ETACS, JTACS and NMT-450/900 cellular phones.

The software is written in I-Basic to control the test set and other instruments such as external power supplies. Tests in the software packages are derived from international standards for various radios.

As the set performs the tests, it displays a pass-fail indication next to each result. A printer may be used to produce a permanent copy of test results to keep with the radio.

The more accurate and repeatable the test results, the better job a technician can do in repairing radios, which in turn makes a service shop more competitive. Some steps taken to deliver improved testing performance include:

• *Tolerances*—Each measurement function is specified with tolerances that ensure the measurement of radio performance, not test set errors. For example, the RF signal generator output level is specified to ±1.5dB accuracy at levels as low as 0.1μV or less. Accuracy at the lowest levels is most impor-

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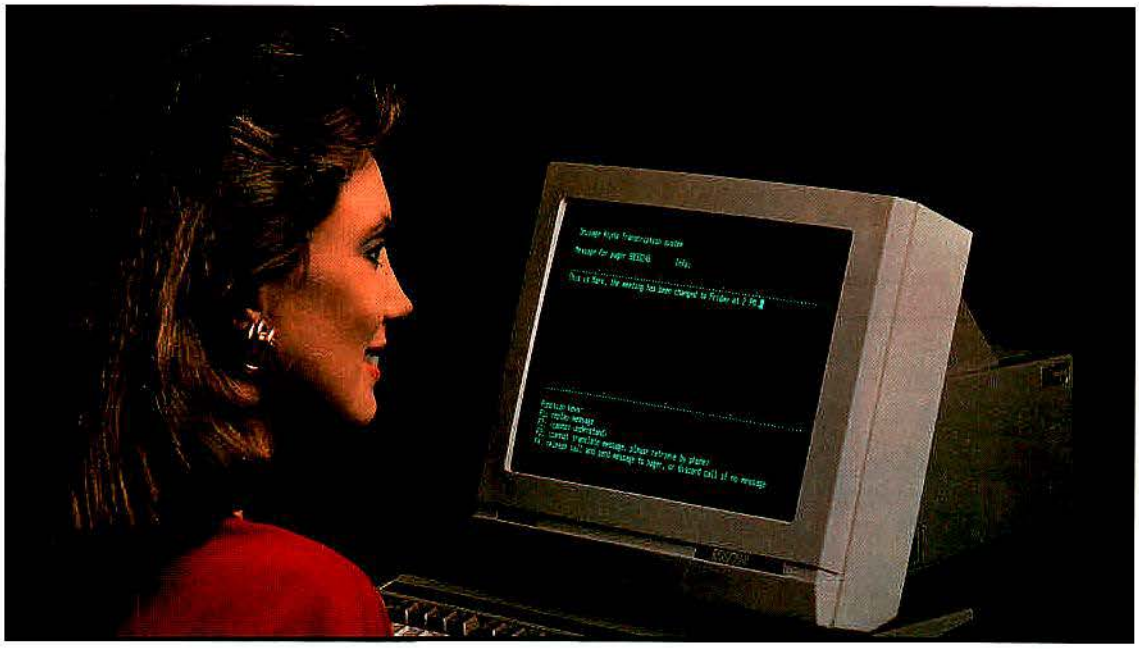

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Alpha Transcription from Unipage can help put your company in the lead. This new paging option answers a growing demand, distributing alpha pages directly to subscribers from the voice messages stored in their mailboxes.

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The system provides the best combination of automated and manual operation that today's technology can provide, and supplies a platform that can be used for future speech recognition systems as that technology matures.

By combining voice storage technology with message queuing and an advanced operator interface, the Unipage system offers alpha messaging service with fewer operators and greater cost efficiency than a "live" operator message center.

Alpha Convenience

The caller to an alpha pager can either enter a display message for the pager, record a voice message, or both. If a voice message is recorded, it is placed in queue for transcription by an operator. All available operators are notified of pending calls, and any operator can transcriber the call.

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There is also an optional TAS interface available that provides interface to most existing automated TAS systems. Other connectivity options are in development.

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tant because that is where receiver sensitivity should be measured to ensure reception under the worst conditions.

• *Signal leakage*—A more subtle aspect of low-level signal generator performance is repeatability. Stray RF fields can leak from the test set and affect measurements made at low levels. When such leakage is coupled into the receiver, it may be as strong or stronger than the signal at the antenna port. Each test set is tested for leakage with a special antenna. As an extra measure of protection, the set's internal mechanical design allows RF modules to be serviced without degrading the leakage performance.

• *Spectral purity*—The signal generator's spectral purity is important in making accurate hum and noise measurements. For example, residual frequency modulation of the signal generator limits hum and noise measurements on FM radios. The test set specification for residual FM is less than 20Hz. Typically, the residual FM is less than 12Hz. Such a low level allows hum and noise measurements up to 45dB, which is the Electronics Industries Association (EIA) standard.

• *Frequency*—The signal generator's and RF analyzer's frequency accuracy and resolution limit how closely you can set and check a transceiver's center frequency. Most modern test sets are frequency synthesized, so their frequency accuracy depends on the accuracy of the internal crystal time base that controls the synthesizer. Crystal oscillator stability generally is sufficient, so the frequency accuracy of newer tests sets usually is not an issue. But frequency resolution is.

To make sure a test set is operational when it is needed, it should be the most reliable piece of equipment you own.

Frequency resolution, which refers to the minimum setability of the generator and analyzer, may be a factor that limits how accurately you can set or check a mobile radio's center frequency. A resolution of 100Hz, for example, is 0.5% of a 20kHz-wide channel. A 1Hz resolution is 0.05% of a 20kHz-wide channel. The test set delivers 1Hz resolution, virtually eliminating concern over setting carrier frequency.

To make sure a test set is operational when it is needed, it should be the most reliable piece of equipment you own. Reliability goals for the 8920A test set are based on the most stringent portable field applications. This means you do not need to keep the set on the bench in fear it will suffer in the harsh environment at a repeater site or installation shop. It has been subjected to a battery of vibration, temperature and humidity cycles during each stage of the design

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Circle (19) on Fast Fact Card

The set's reliability goals are based on stringent portable field applications.

to ensure that it is fit for true field use.

If a failure does occur, the set's modular design supports quick diagnosis and repair. With a separate repair kit, the set automatically diagnoses failures to the module level, and modules can be replaced in minutes. Modules are available on a 24-hour exchange program.

Packing a lot of equipment into a small package helps to make the right test capability available when you need it.

When first troubleshooting a radio, the test set's 2.0μV sensitivity helps to isolate the problem off the air. Difficult site management interference problems are made easier to solve with the optional spectrum analyzer with full band sweep; synthesized, accurate markers with digital frequency and amplitude readout; 60dB "spurious-free" range; and the ability to dump the complete sweep results to a printer or memory card.

For troubleshooting radio systems, the spectrum analyzer option includes a tracking generator that allows accurate measurement and tuning of the frequency responses of duplexers, multifrequency receiver filter banks and ring combiners. A trace normalization function helps to make quick and accurate measurement of insertion loss through filters, cabling and attenuators, as well as the return loss in antennas.

The tracking generator's flexible, calibrated output level spans −137dBm to +7dBm and can be offset as much as 1GHz from the spectrum analyzer to make IF-to-RF conversion measurements.

To aid troubleshooting, a 50kHz digital oscilloscope is included. The scope function has single-shot and pre-trigger viewing to help to capture burst waveforms. The scope readout accuracy is enhanced with a marker capability that gives a digital readout of precise amplitude at any point across the time sweep. As can the spectrum analyzer trace, the scope trace can be printed.

For functional testing on radios that use signaling, the test set has signaling encoding and decoding capability, including tone sequence; digital sequence; dual-tone, multiple-frequency (DTMF); trunking; and cellular.

The most common signaling standards are selected from a list. Others are supported with built-in tone sequence and digital sequence generators.

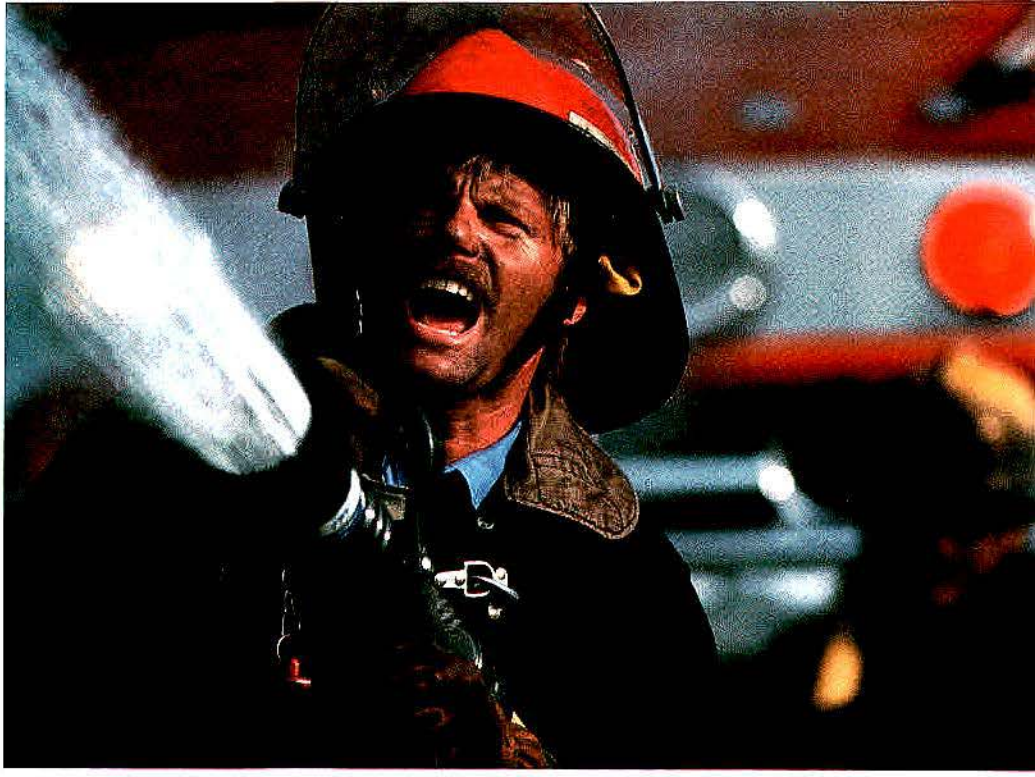
The decoder displays tone, DTMF or digital sequence transmitted and the duration of the tone or tone pairs.

For testing pager transmitters, the decoder displays the address and code transmitted, the message transmitted and the transmission rate.

Combination test set

The field-portable test set represents the next step in a process that has seen continual combination and miniaturization of production line radio test equipment. Advice from customers who already have used rack-and-stack test equipment and from radio service shop owners and technicians led to the design of this next generation of test equipment.

When every second counts...



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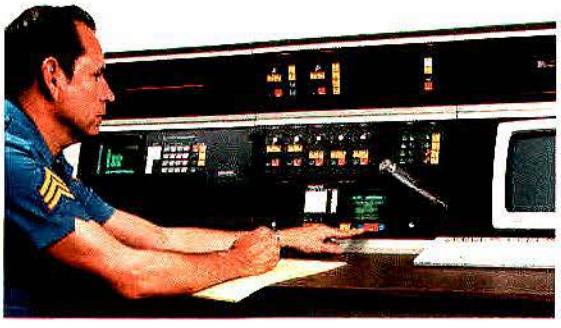

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Circle (21) on Fast Facts Card

Choosing power supplies for station equipment

Magnetic, linear and switching regulator power supplies have specific advantages and disadvantages. Knowing the differences will help you to choose the right kind of supply for radio communications facilities.

By Eddie Ritz and Ron Stopelli

Selecting a regulated dc power supply involves tradeoffs among price, performance and reliability. An overview of the three major types of power supplies' characteristics may help you to make an informed choice. Definitions appear on pages 28, 30 and 32.

Magnetic regulator

The magnetic regulator power supply obtains regulation by controlling the power transformer's magnetic field. (See Figure 1 below.) The supply has several capabilities and advantages:

► *Simplicity*—The regulating function is incorporated in the power transformer.

► *Ruggedness*—The components are inherently rugged. Conservative design can improve overall ruggedness. The power supply withstands high temperature, high humidity and vibration. The magnetic regulator power supply is the toughest type of power supply.

► *EMI/RFI susceptibility*—The power supply is not susceptible to EMI and RFI. It is the only type of regulated supply that can be operated in a strong RF field, such as the field near a radio transmitter, without special precautions.

► *Overvoltage protection*—OVP is an inherent characteristic of the magnetic regulated power supply because any failure mode drops the output voltage.

► *Overcurrent protection*—The power supply has inherent OVC protection, but the current-limiting characteristic allows the supply to deliver large, instantaneous peak currents, including peak currents demanded by RF amplifiers. Such peak currents would push the active limiter circuits in linear and switching power supply regulators into limiting, collapsing the supply output voltage and causing load malfunctions.

► *Reliability*—Historically, the magnetic regulator power supply has been highly reliable because it is simple and rugged. Troubleshooting and repair are easy. The output voltage is fixed, so no field adjustments are necessary or possible. A fixed output voltage can be an advantage for equipment exposed to tampering, and whose misadjustment could have serious consequences.

The magnetic regulator power supply has some limitations and disadvantages:

► *Line frequency*—The magnetic regulator's primary limitation is its restricted line-frequency operating range: 3Hz above and below its design center frequency. For example, a regulator designed for the 60Hz North American line frequency has a 57Hz-to-63Hz operating range. A regulator designed for the 50Hz European line frequency operates from 47Hz to 53Hz. The 6Hz span is insufficient for one regulator to cover both line frequencies. Therefore, export equipment requires specific transformers according to destination.

► *Magnetic field*—A magnetic field transformer has a higher magnetic field than transformers used in linear and switching power supplies, so it may not be suitable for such applications as an installation beside a cathode-ray tube (CRT).

► *Ripple and noise*—Because the magnetic regulator mechanism does not reduce ripple as much as a linear regulator mechanism, the magnetic regulator power supply has inherently higher ripple that ranges from 25mV to 300mV, depending on the filter configuration.

► *Recovery time*—The magnetic regulator power supply's recovery time is slower than it is for the other two types of power supplies, but the output

Ritz is president of Ritz Electronics, New Dundee, Ontario. Stopelli is the company's engineering manager.

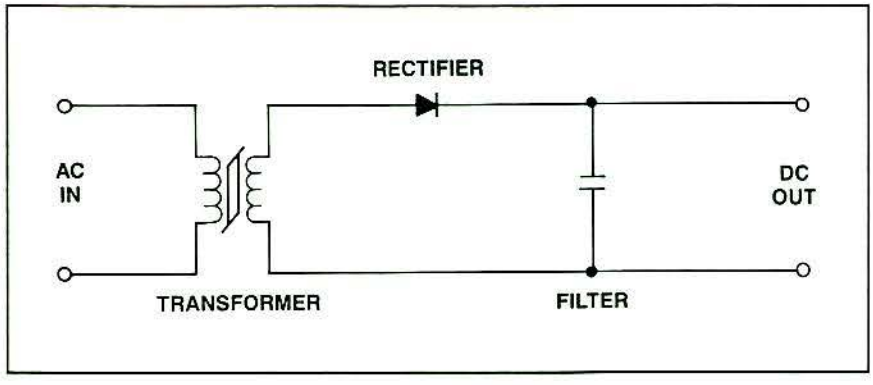

Figure 1. The magnetic regulator power supply is so named because regulation is obtained by controlling the magnetic field in the power transformer.

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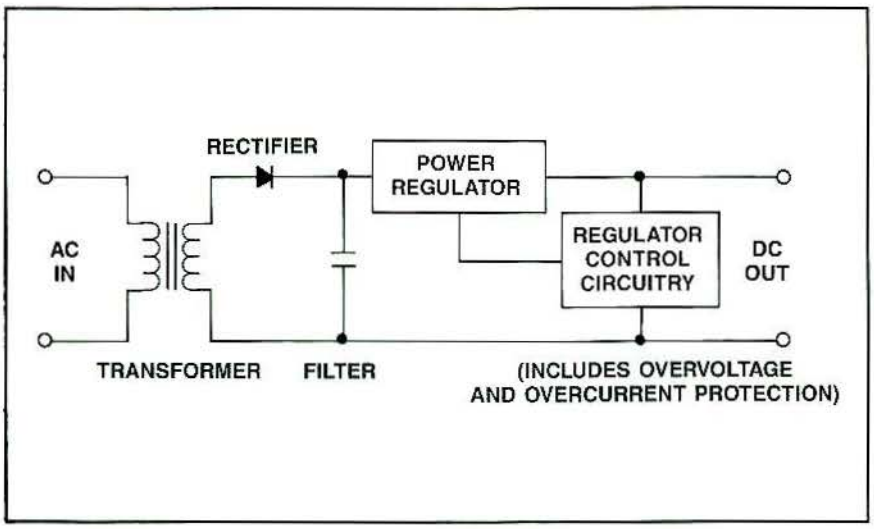

Figure 2. The linear regulator power supply is more complex than the magnetic regulator power supply. The availability of integrated circuits specifically designed for linear regulation has encouraged the technology's use.

voltage drop can be reduced with large output capacitors.

The linear regulator power supply regulates by dropping excess voltage with a power transistor used as a variable resistance. The process dissipates a fair amount of power, reducing the linear regulator power supply's efficiency to the lowest of the three types. Nonetheless, the linear regulator is the most commonly used of the three types.

As Figure 2 at the left shows, the linear regulator power supply is more complex than the magnetic regulator power supply. But the availability of a multitude of integrated circuits (ICs) specifically designed for linear regulation encourages the technology's use in many applications, such as the on-board and slot regulator applications. Because of its tight regulation, low hum and low noise, the linear regulator power supply is the most common variable power supply used in laboratories.

The linear regulator power supply has several capabilities and advantages:

► *Regulation*—The use of sophisticated yet readily available ICs allows the linear regulator power supply to be designed to deliver tight regulation fairly easily.

► *Hum and noise*—Because of its usually tight regulation and the regulator's placement after the filters, the linear regulation power supply has the best hum and noise performance of the three types of supplies.

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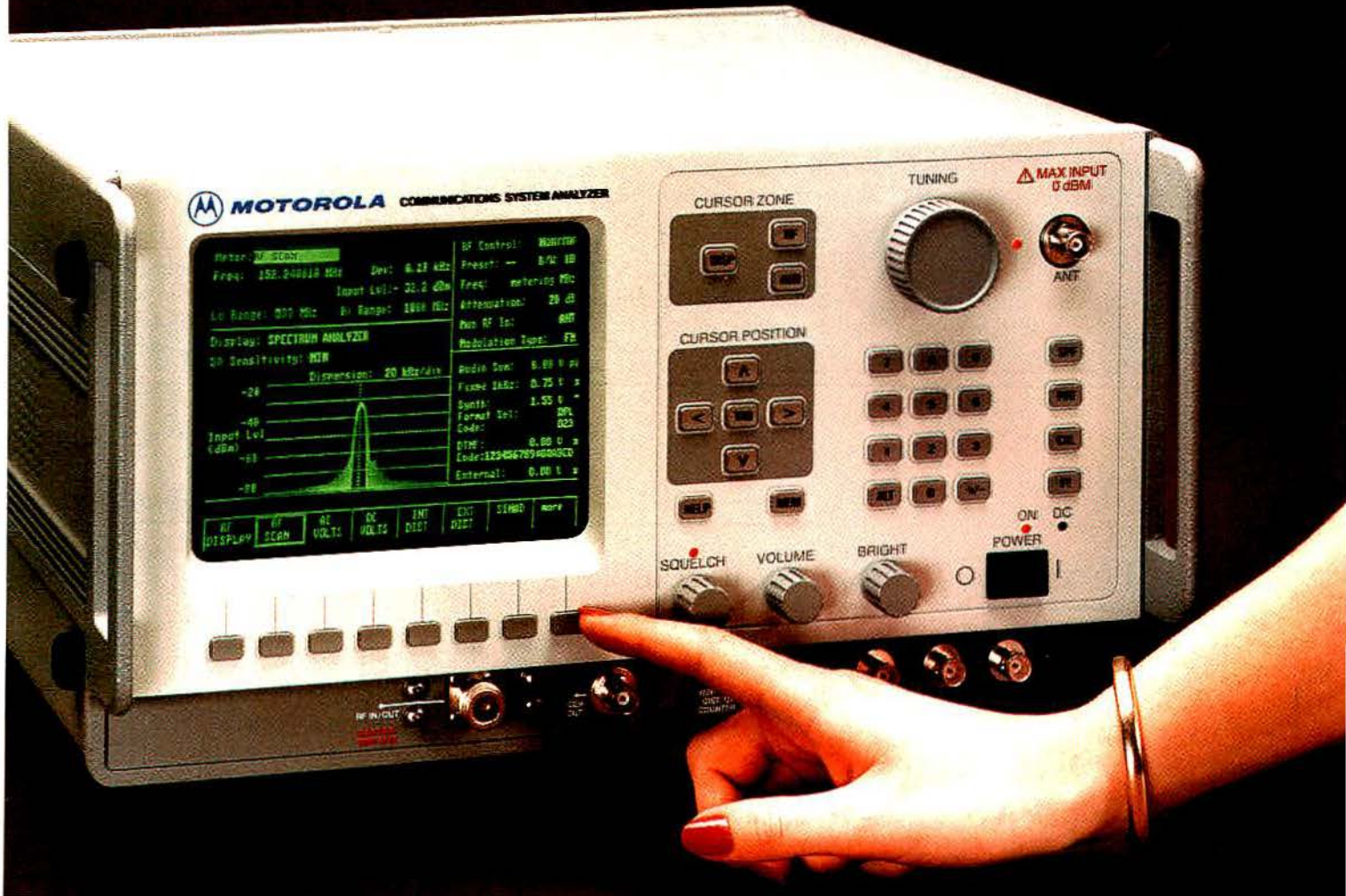

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MOTOROLA

Circle (24) on Fast Fact Card

Definitions

Cooling clearance. The space required around the power supply for proper air circulation to cool the supply.

Duty cycle. The ratio of times during which a supply is delivering and not delivering power to the output. The duty cycle specification applies to power supplies designed for intermittent duty. It is expressed as a time ratio: for example, 3 minutes on and 6 minutes off (33% duty cycle). This specification often is misunderstood.

EMI and RFI generation. Switching circuits generate RF in direct proportion to switching speed and the amount of current passed. Switching regulators, therefore, are a primary RFI source. This situation is widely recognized by various national and international standards and by regulatory authorities that have issued rather stringent mandatory emission limits.

EMI and RFI susceptibility. Electromagnetic interference (EMI) and radio frequency interference (RFI) can disrupt a power supply regulator's operation in the same way that a radio transmitter signal might interfere with TV reception.

Line regulation. The change in supply output voltage that corresponds with a ±10% change in a nominal 117Vac power line voltage.

► *Recovery*—The supply has the fastest recovery time of the three types of supplies.

The linear regulator power supply has some limitations and disadvantages:

► *Output current*—Maximum output current is limited by practical considerations to approximately 20A. Higher output currents are possible, but at a considerably increased cost.

► *EMI/RFI susceptibility*—The linear regulator power supply's susceptibility to EMI and RFI depends largely upon its design. Seldom is a unit's susceptibility described in its published specifications, leaving the buyer to trust in the manufacturer's reputation. Unshielded supplies are particularly vulnerable. Great care should be taken in selecting linear regulator power supplies for use with radio communications equipment.

► *OVP*—Regulator failure can cause abnormally high output voltages, thus inflicting serious damage to sensitive circuits, such as digital ICs and RF devices. To reduce the possibility of

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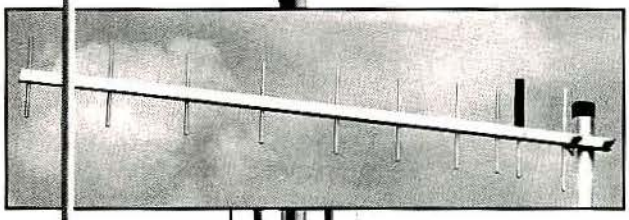
PERFORMANCE ANTENNAS



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Circle (26) on Fast Facts Card

Load regulation. The change in supply output voltage caused by a change from minimum to maximum rated load current. The load is the equipment being fed by the power supply.

MTBF. Mean time between failures—the average time expected to elapse between failures, expressed in operating hours.

Minimum load. The lowest load—the minimum output current required for proper operation, usually from 5% to 10% of full output rating.

Overcurrent protection. Also called current limiting, overcurrent protection protects the power supply against overloads, such as output short circuits.

OVP. Overvoltage protection refers to the protection of the load, that is, the equipment connected to the power supply output, to prevent the supply from delivering catastrophic output voltages should the regulator circuits fail.

Recovery time. The time required for the output voltage to return to within 1% of its setting following a sudden change in load current. All regulators take a definite amount of time to correct for load changes. The slower the regulator, the lower the voltage drops for a sudden increase in load current. Conversely, the voltage rises for a sudden decrease in load current. Digital equipment, generally, and computers, particularly, are sensitive to voltage drops and spikes of even short duration. Therefore, recovery time should be kept in mind when selecting power supplies for such applications.

high output voltages, a crowbar usually is available as an add-on option. The crowbar circuit monitors the dc output. Upon sensing an overvoltage, the crowbar clamps the regulator line input to ground, thus blowing the regulator's fuse and shutting down the supply.

For years, most power supply manufacturers used a simple silicon-controlled rectifier (SCR) and Zener diode circuit, which in many respects was inadequate. An IC crowbar offers superior protection.

► *Overcurrent protection*—Without overcurrent (OVC) protection to limit maximum current, regulators could be damaged easily. Therefore, overcurrent protection is included in most power supplies. OVC protection action reduces output voltage fairly rapidly to zero as output current exceeds the OVC protection setting, usually 10% to 20% above normal output. Although this action protects the supply, it adversely affects the operation of a load that demands fairly high peak currents.

► *Efficiency*—Because of its dissipa-

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Ripple and noise. Ideally, regulated supplies deliver pure direct current. In practice, though, some products of the power conversion process are not fully suppressed, so they appear at the output. These products usually take the form of 120Hz hum in magnetic and linear power supplies and high-frequency switching products in switching power supplies.

T_a range. The ambient temperature range—the range of temperatures in the power supply's environment within which the supply delivers maximum rated output power. Some vendors list the maximum output currents for various temperatures above maximum T_a specified for full output. For example, a specification might read: output current 1.5A to 50°C; 1.0A to 60°C; 0.5A to 70°C.

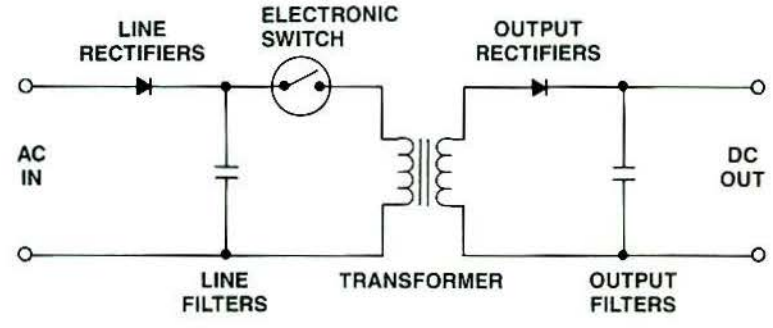


Figure 3. The switching regulator power supply converts ac power to rectified and filtered dc. A power switch converts the dc to high-frequency pulses applied to the transformer primary. Secondary windings deliver these pulses to rectifiers and filters that convert them back to dc.

tive regulator, the linear regulator power supply has the lowest efficiency of the three types. The low efficiency requires the use of large heat sinks, which increase the weight and the clearance requirements for cooling.

Switching regulator

Although switching regulator power supplies long have been available, only in the last two or three years have they entered an economical price range, thanks to the improved availability of the rather sophisticated components used in high-power switching circuits.

Figure 3 at the left shows that the switcher uses two sets of rectifiers and filters, one for the line input and one for the dc output. The 60Hz ac power is converted to rectified and filtered dc. Then the power switch converts the dc to relatively high-frequency, 20kHz-to-50kHz pulses applied to the transformer primary. Each secondary winding delivers these pulses to rectifiers and filters that convert them to direct current.

Regulation is achieved by changing the width (duration) of the pulses delivered to the transformer by the power switch, which is turned on and off rapidly by the regulator control circuit—hence the common name for the supply: switcher.

Supervisory circuits monitor and control other functions, such as overvoltage protection; undervoltage protection; overcurrent protection; erratic switching that leads to loss of regulation; start-up current inrush limiting; and power switch temperature.

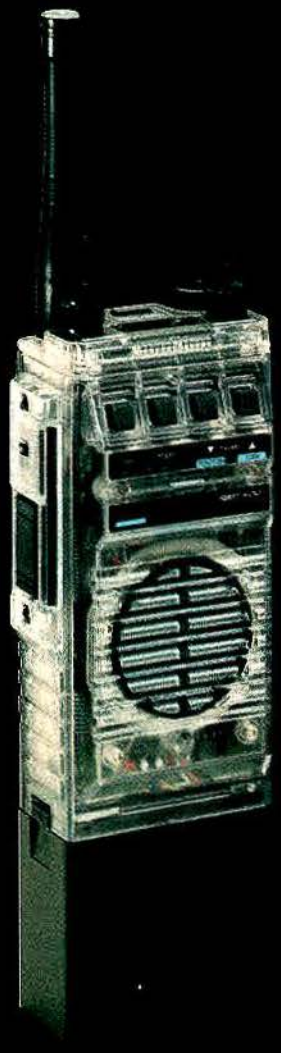
The increased complexity required to support these extra features may reduce the supply's reliability because there are so many things that can go wrong. Moreover, what monitors the monitors?

Although all switchers use the same basic operating principle, the implementation varies widely among suppliers, even from one model to another because the technology is not yet mature. Each manufacturer experiments with different approaches in an effort to optimize each design.

The switching regulator power supply has several capabilities and advantages:

► *Output voltage range*—This power supply's output voltage range is the

RSP 400



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widest of all three types. The switcher has been used for the high-voltage supply in most oscilloscopes (up to 20kV) and TV receivers (up to 30kV).

► *Output current range*—The switcher's output current range is much wider than that of the linear regulator power supply's because of its high efficiency.

► *Efficiency*—The switching mode of operation has the advantage of minimizing losses in the regulator control element, which is represented in the block diagram as the power switch. The primary benefit is a lower temperature rise, which translates into smaller heat sinks, less weight, smaller size and a smaller cooling clearance.

► *Size and weight*—Because of its high operating frequency, the switching supply transformer is the smallest and lightest. For the same reason, smaller filter capacitors can be used for an equivalent current rating. Along with smaller heat sinks, these factors make the switcher the smallest and lightest supply for a given power rating.

► *Cooling clearance*—Low power dissipation allows switching power supplies to be installed with less clearance than is required for linear regulator power supplies.

The switching regulator power supply has some limitations and disadvantages:

► *Load regulation*—Most switchers' regulator control circuit monitors only one output, usually called the main output. This circuit results in good regulation (±1%) for single-output supplies and for the main output of multiple-output supplies. But the regulation is poorer (±2% to ±5%) for secondary outputs on multiple-output supplies. To improve load regulation for secondary outputs, some switching supplies include linear regulators on the secondary outputs. This approach reduces the efficiency, thus trading away one of the switcher's main advantages.

Low power dissipation allows switching power supplies to be installed with less clearance...

► *Ripple and noise*—Output ripple includes two components: 120Hz hum left over from line rectification and filtering, and high-frequency switching products. Even a shielded, filtered unit emits high-frequency components from output leads that act as antennas. The emissions can interfere with the operation of other electronic equipment.

► *EMI/RFI susceptibility*—The same general comments about the linear regulator power supply apply to the switching regulator power supply. Because of

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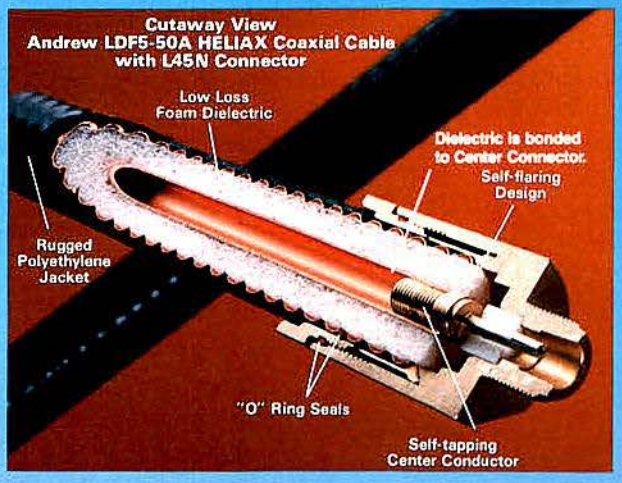

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Decibel, a leader in base station antennas, is also a top seller of HELIAX cables, connectors and accessories. Here's why:

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Decibel antennas must pass tests for intermodulation generators and power handling capability. Andrew cables and connectors are designed to resist moisture and RF leakage.

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Decibel offers more than a hundred 30-1000 MHz antennas and the antenna systems equipment you need to complete your site, including HELIAX LDF® foam, air dielectric and Superflexible cables and accessories.

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Customers want good service.

Decibel stocks almost all sizes of cables and cuts them to length with connectors fitted at one or both ends, if desired. The antenna end of the cable is wound on the outside of the coil so that it can be hoisted directly up the tower, with trimming done from the transmitter end, if needed.

Customers want good prices.

Although Decibel and Andrew prices may be a little higher initially, they're actually lower in the long run. Bottom line costs are actually less because your systems perform better and last longer.

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For more information

Contact Marketing, Decibel Products,
P.O. Box 569610, Dallas TX 75356-9610.
Telephone (214) 631-0310.
FAX (214) 631-4706.

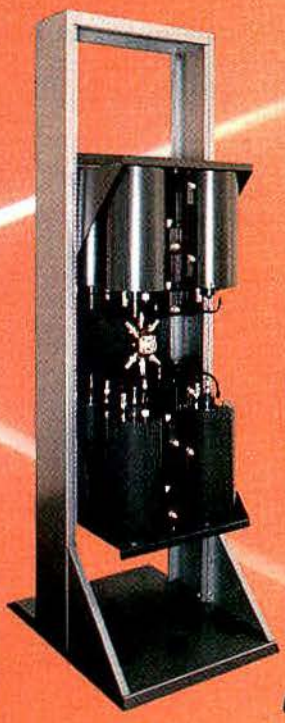
Decibel antennas pictured (L to R) are DB408, DB859, DB559

Decibel is an Alliance Telecommunications Company.

Decibel designs systems that communicate . . . quality!

DB8980 Tower Top Amplifier for 806-901 MHz (below) and Bandpass Cavity Filter for 30-50 MHz.

Filtering



DB8062H (below) and DB9072 Tx Combiners handle, respectively, 150 or 200 watts per channel* for 850-960 MHz.

In a recent survey Decibel's filter products were selected the "best" almost three to one! Thanks to quality and performance.

You can choose Decibel with confidence when you need cavity filters, duplexers, Tx combiners, Rx multicouplers, tower top amplifiers, I.M. protection panels, ferrite isolators and couplers.

High Q copper cavities, completely soldered, are used in 4, 5, 5½, 6¾ and 11 inch sizes, aluminum cavities in 5, 8 and 10 inch sizes.

An Invar steel tuning piston — with almost no expansion — keeps cavities in tune in all temperatures.

Current carrying elements are made of copper or silver plated brass, including the center conductor.

Beryllium copper fingerstock with spring compression is used to maintain positive contact between fixed and moving parts of the center conductor.

Unique helical resonators with steel or copper pistons are used in some cavities to achieve a 3 to 1 size reduction.

Some filters utilize stripline and interdigital or combline technology.

High power models and international frequencies are available.

Decibel continually updates products and adds new ones to meet your frequency and system requirements.

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An Alliance Telecommunications Company

Decibel designs systems that communicate . . . quality!

Filtering Equipment	Frequency-MHz	Power-watts	Features
Bandpass Cavity Filters	30-174, 225-512, 806-1000	150-400	Field tunable, adjustable selectivity
SHAPE FACTORED FILTERS®	118-174, 225-470, 806-960	150-300	Broad, flat, steep-slopped rejection
Notch & Bandpass Reject Filters	30-50, 148-512, 806-960	125-400	Reduces interference up to 100 dB
Bandpass & Band Reject Duplexers	138-174, 216-220, 406-512	150-400	Isolates Rx from Tx up to 100 dB
Duplexers	824-892, 806-960	150-600	Cavity, interdigital & stripline construction
Tx Combiners & Accessories	138-174, 200-512, 850-960	to 200/Ch*	Combines 2 to 20 Tx as close as 250 KHz
Hybrid Tx Combiners	118-174, 406-512, 806-1000	125-350	Combines 2 to 8 Tx at little or no separation
Isolators & Circulators	118-174, 406-512, 806-960	150-400	Single, dual or high power ferrites
I.M. Protection Panels	118-174, 406-512, 806-960	150-350	Single or dual isolators, harmonic filters
Rx Multicouplers	30-174, 200-512, 806-901	—	Allows 4 to 32 Rx on one antenna
Tower Top Amplifiers	406-470, 806-901	—	Balances Rx "talk-back" with Tx "talk-out"
Cross Band Coupler	406-512 and 806-932	to 700	One transmission line, two frequency ranges

*700 or 1200 watts maximum output per system.

SHAPE FACTORED FILTER is a registered trademark of Decibel Products.

Circle (34) on Fast Fact Card

the switching mode of operation, it is more difficult to render this type of supply RFI-proof. A metal case and input-output filters are important.

► *EMI/RFI generation*—The switcher that generates EMI and RFI can cause many problems. The rapid switching of large currents generates a wide spectrum of harmonics of the switching frequency. These harmonics may extend into the VHF bands, including TV and FM broadcasting frequencies.

Some of these RF harmonics can interfere with the operation of equipment into which the supply may be built, and they can interfere with surrounding equipment, too. To prevent interference, the switch must be enclosed in an RF-tight metal case, and all input and output leads should be filtered.

Some switching supply manufacturers offer RFI suppression enclosures and filters as options. Thus, the buyer should be aware of the possible additional expenses when comparing costs.

► *Reliability and troubleshooting*—The switching supply is the most complex of the three, inevitably leading to more failures. At the same time, the extensive and complex circuitry is more difficult to troubleshoot.

The large span of mean time between failures (MTBF) given in the comparison summary at the left reflects the wide spread in quality of the available power supply products. This variation is especially evident in certain imports designed to be sold at low prices. In some cases, electrical and mechanical designs used for these units are poor and outright dangerous. Estimating reliability for these units is practically impossible.

► *Applications*—The switcher is best suited for applications requiring a lightweight, high-efficiency supply with a smaller cooling clearance than the clearance required by linear regulator power supplies. The switcher is well suited for computer applications where weight is of paramount importance and the equipment has high noise immunity.

The switcher is not well suited for communications, medical, geophysical and audio equipment applications unless the supply is filtered and shielded far beyond ordinary standards.

Table 1—Comparison summary for the three power supply types.

CHARACTERISTIC	MR (MAGNETIC)	LR (LINEAR)	SR (SWITCHING)
Output voltage range	5V to several kV	1V to 50V	2V to several kV
Output current range	5A to over 100A	to 20A	to 100A
Load regulation	2% to 6%	0.01% to 2%	0.1% to 3% (M)
Ripple/noise	25-300 mV	1mV	10-100 mV (M)
Recovery	16-200 mS	50-200 μS	50μS to 10 mS
RFI sensitivity	nil	design dependent	design dependent
RFI generated	nil	nil	high
OVP	inherent	crowbar	crowbar
OCP	inherent	limiter	limiter
Min. load	10%	0	5-30%
Efficiency	65-85%	40-60%	60-88%
—Physical—			
Weight	medium	high	low
Size	medium	large	small
Cooling	convection	convection or fan	convection or fan
Cooling clearance	small	large	medium
—Environmental—			
T_a range	−30°C to +70°C	0°C to 50°C	0°C to 50°C
Humidity	to 98%	to 85%	to 85%
Vibration	high	medium	medium-low
Shock	high	medium	medium-low
—Reliability—			
MTBF (hours)	>20,000	3,000 - 15,000	2,000 - 10,000
Complexity	low	medium	high
Troubleshooting	very easy	fairly difficult	most difficult
—Cost—			
Cost ratio	1	1.5-2.5	1.5-3

Notes:
(1) Ac line input voltage range for all types — 117Vac ± 10%.
(2) The range of characteristic values indicated is a 'typical' average. Other ranges and better performance can usually be obtained at extra cost.
(M) Main output only.

General considerations

To purchase anything by price alone is asking for trouble because someone always is willing to cut the price until even the function, let alone the performance, becomes an optional extra.

A better way to purchase is to use the cost-of-ownership concept because it reflects not only the purchase price but reliability and other factors. In addition, purchasing from a reputable manufacturer offers unadvertised benefits that

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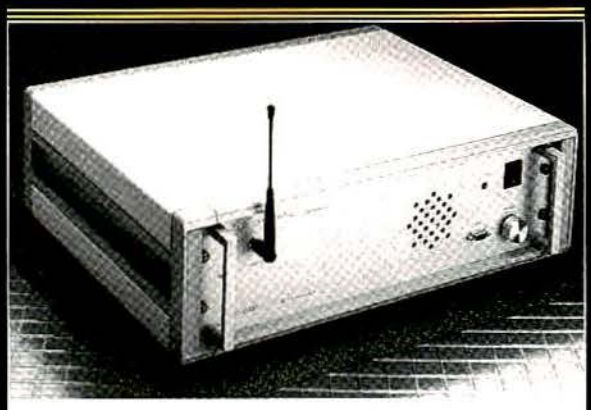

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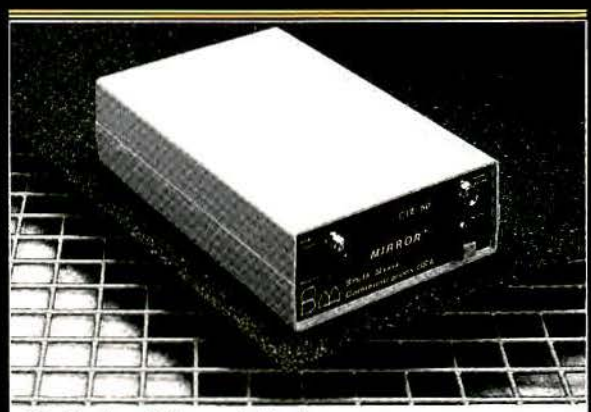
The ART-875 is a dedicated Cellular Test instrument of the highest standards. The Cell Site Simulator gives you the ability to evaluate the performance of your cellular telephones by accurately measuring Carrier Frequency, Power, Modulation and Audio Frequencies. Testing on Channels 666 and 832, Wireline or Nonwireline. This unit is completely portable with RS232 port for printouts. This unit has received Carrier acceptance.



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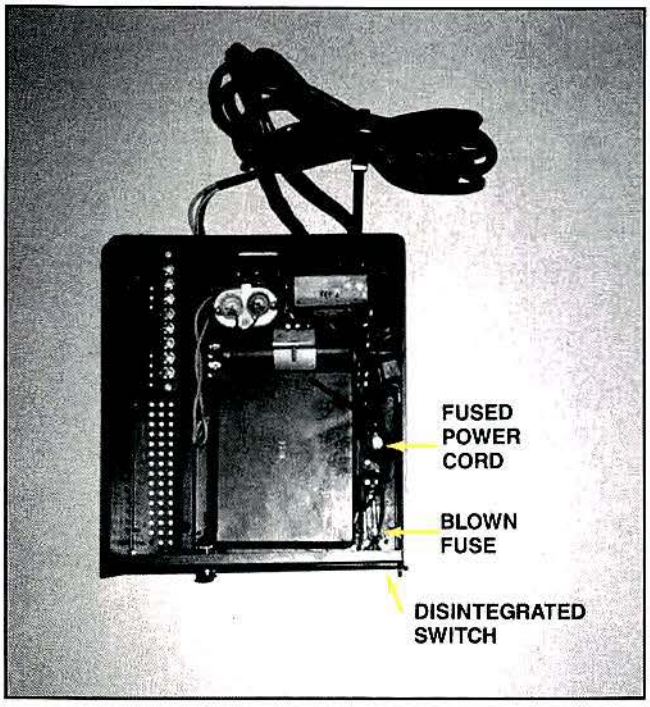
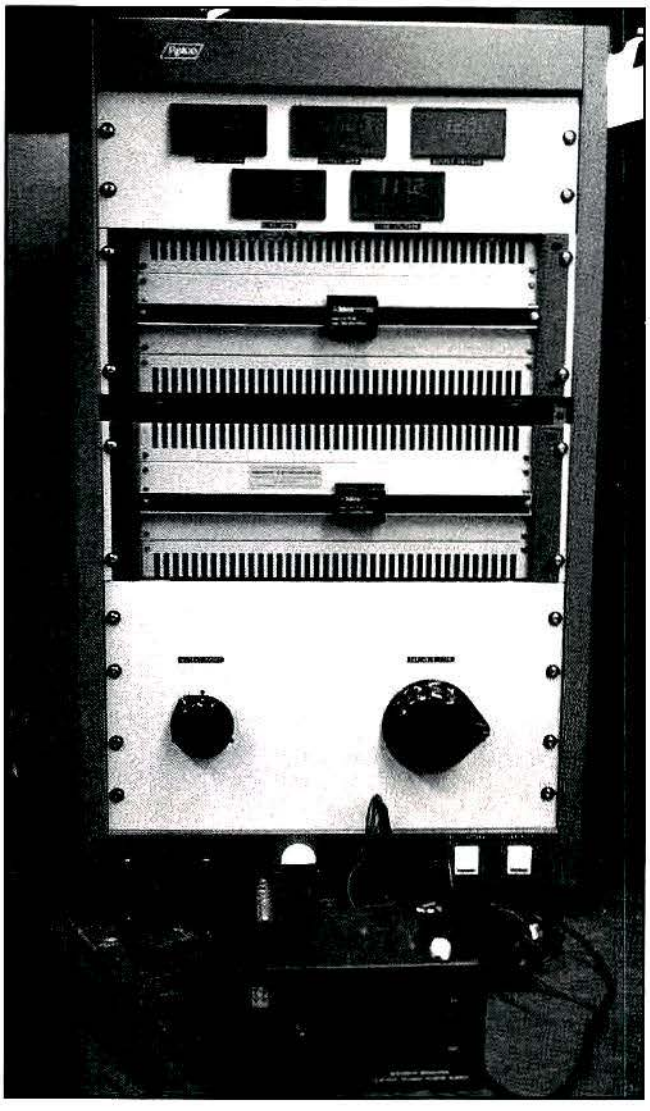


The magnetic regulator power supply shown above evidently took a direct lightning strike. The switch disintegrated, the fuse blew and the line cord welded together.

As shown at the right, the power supply operated normally when checked. The power supply under test shows normal operating conditions as indicated by the meter readings. Equipment connected to the supply was protected by it and thus was undamaged by the lightning strike.

Readings, top left to right: Output ripple, .005; output amps, 10.07; and output voltage, 12.00.

Readings, next row, from left: Line amps, 2.06; line voltage, 117.2. (The red-against-black readouts do not show well in a black-and-white reproduction.)



make life easier in the long run.

► *Purchasing*—There are two basic ways to purchase power supplies.

(1) Issue a specification listing the desired characteristics, values, limits and tolerances.

Original equipment manufacturers (OEMs) prefer this method because it allows them either to find a stock supply that meets or exceeds their specifications or, failing that, to request quotations for custom-built units. Those who purchase small quantities of power supplies normally do not believe the time and effort required to use this method can be justified.

(2) Write a performance specification that describes what the supply is expected to do and under what conditions.

This method is popular with consultants in all specialties. In effect, it asks the supplier to lend his expertise to assist the buyer in making an appropriate choice. It does not obligate the prospective buyer. It bypasses the time-consuming job of collecting and evaluating catalogs and specifications. To be successful, requests should be sent only to solid, reputable companies.

► *Specifications and ratings*—The relative accuracy of published ratings deserves a special mention because some vendors design supplies for intermittent, rather than continuous, duty and fail to mention it in their specifications. Other vendors refer ambiguously to the duty cycle with phrases such as "continuously intermittent," whatever that means. (See "duty cycle" under "Definitions.")

"Intermittent duty" means the supply cannot deliver full power continuously. For example, a clear specification might read: "20A continuous; 40A intermittent; five minutes on, five minutes off; 50% duty cycle" or any other combination of time and power level figures that result in the same temperature rise in the power supply.

It may be misleading if an unqualified 40A rating, for example, appears on the shipping box and on the supply's front panel and the actual 50% duty cycle rating for the 40A current level appears only in the instruction manual.

► *Performance*—An important factor in obtaining satisfactory performance from a regulated supply is the selection of the correct regulator type for the application.

When power supplies are purchased in quantity, performance should be verified under actual worst-case working

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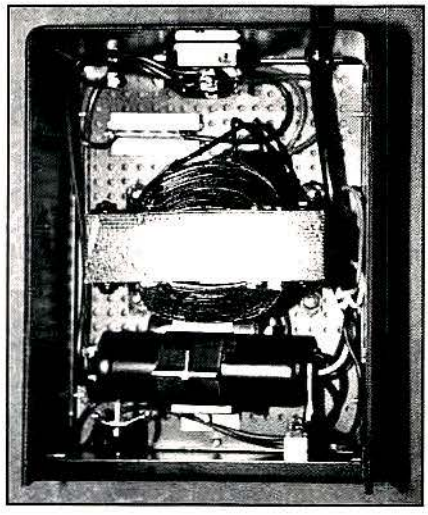
conditions. Many vendors lend one or more samples or sell them at a nominal price for this purpose. "Worst-case" means a combination of the worst conditions the supply may encounter in the field, such as high line voltage (130Vac), full rated load, the highest ambient temperature and continuous operation (eight hours minimum).

► *Reliability*—Except for military and industrial equipment, power supply reliability usually is not specified by the vendor. The best way to obtain a supply with high reliability is to buy it from a reputable, quality-concious manufacturer.

High reliability is desirable because a reduction in reliability of 10%, for example, could more than offset a comparable reduction in price.



A 13.8V, 10A magnetic regulator power supply. This type of supply has demonstrated a failure rate of less than 0.5%.

The main cause of power supply failure, in the long run, is heat. Conservatively designed equipment generally runs cooler and exhibits greater reliability.

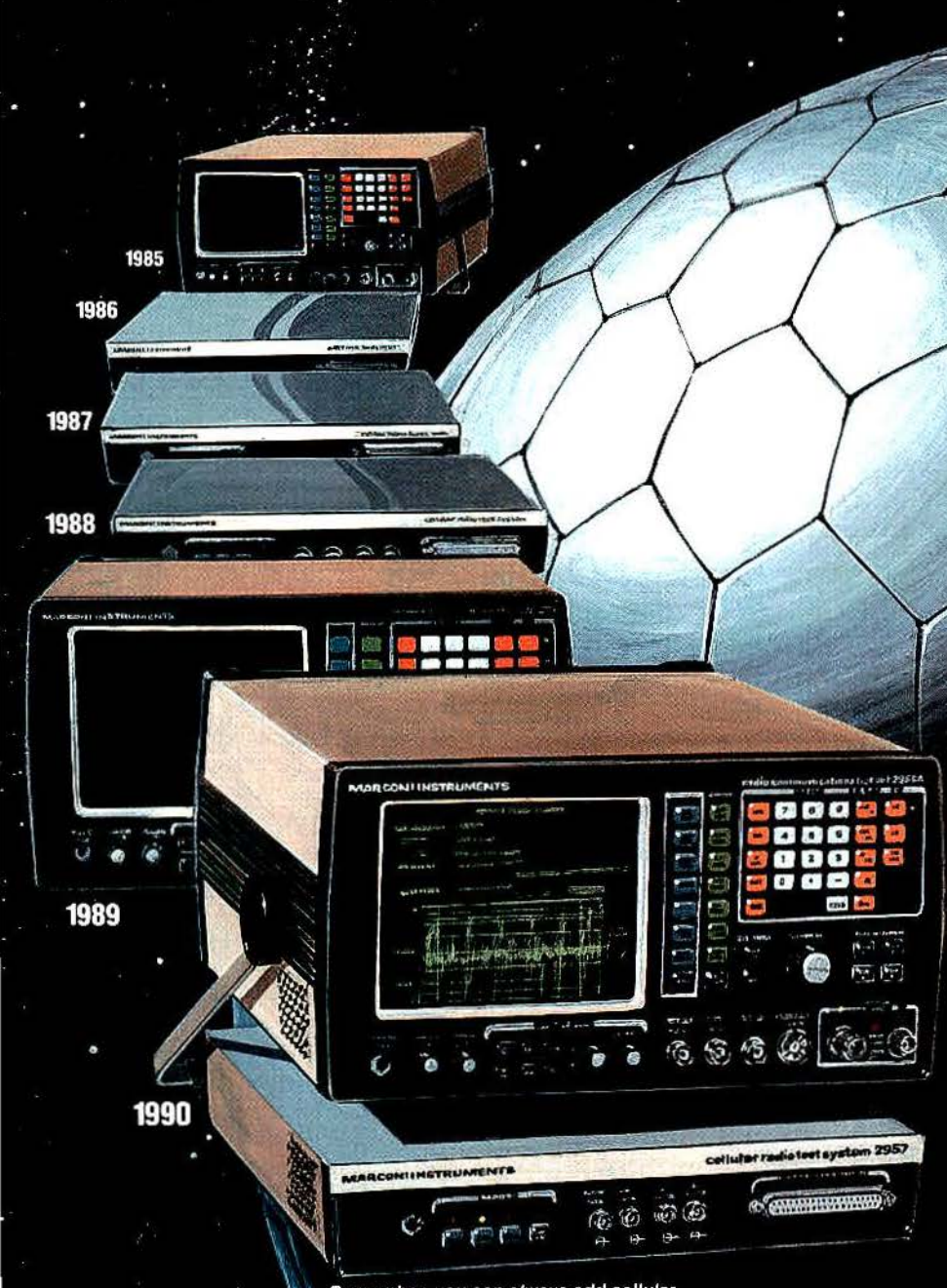
Duty-cycle specifications reflect a supply's heat dissipation capability. A unit rated at 40A and a 50% duty cycle could in fact be a 20A supply capable of delivering 40A for short periods. Such a mode of operation easily is possible with magnetic regulators. But it leads to large temperature excursions and premature failure with linear regulators. Most switchers could not even deliver the large peaks.

► *Certification*—Approvals by national standards agencies, such as UL in the United States, CSA in Canada and VDE in Germany, are important. Approvals generally are issued to certify safety with respect to fire and shock hazards. Since the introduction of switching power supplies, the FCC has issued regulations regarding EMI and RFI compliance certification.

Statements such as "designed to meet" and "meets" a certain standard do not necessarily mean that the unit actually has been approved or certified as complying with the regulations.

The better a purchaser understands the differences among the three major types of power supplies, the reputation of the vendor and the nature of his own application, the better his chances of making an informed decision.

Off-air sensitivity and full duplex testing – the best of both worlds



Remember, you can always add cellular radio test capability to the model 2955. Simply attach the external adaptor and you are in business.

The Marconi Service Monitor has constantly evolved from its beginnings by adding features and improving performance. Now the new 2955R adds 2 μV sensitivity for remote measurements.

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For details on Marconi's current line of radio communications and cellular test sets or to discuss your requirements; contact:

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How long will my pager battery last?

Use this article's equations to calculate battery life for pagers on your system. You'll discover a precise answer is hard to find. Meanwhile, you may be motivated to improve your system's efficiency.

By James W. Marion and John Lewis

Pager users often ask the deceptively simple question, "How long will my pager battery last?"

For a standard POCSAG numeric display pager, the manufacturer's usual reply is, "About one month" or "Four to six weeks." That typical answer may irritate customers. Almost invariably they want more specific information. Based on their experience with portable radios and tape players, for example, customers expect an exact or close estimation.

Nevertheless, an exact answer can rarely, if ever, be given. Despite its easy use and overall simplicity, the digital pager is complex as far as battery life is concerned. Battery life may vary widely, depending primarily on battery-saver current draw, which is inherent in the digital code format. The paging system itself greatly affects battery-saver current draw, which varies with system efficiency.

Secondary factors affecting battery life include current drawn by the alert options, the display and other features; and current drawn during the RF duty cycle's "off" time.

An overview of all factors affecting pager battery life, including POCSAG battery-saver, paging system traffic and secondary factors, follows.

For a better picture of how various elements of battery life interact, a battery life calculation is provided. The calculation is based on a hypothetical paging system and an NEC model R3D4-4C digital display pager.

The pager no longer is made, but a large population exists in the field. The older model was chosen for the example to simplify the calculation. Calculations for current pager models usually are more complicated because of their advanced features.

Marion manages pager engineering for NEC America's Mobile Radio Division in Richardson, TX. Lewis serves as manager of trials implementation for the Worldwide Wireless Strategy group of BellSouth Enterprises in Atlanta.

What affects pager battery life?

Primary factor

- ☐ Battery-saver current draw

Secondary factors

- ☐ Alert options current draw
- ☐ Display current draw
- ☐ RF duty cycle "off" time current draw
- ☐ Other features' current draw

What improves battery life?

- ☐ Superior system efficiency
- ☐ Proper pager use by customers

Battery-saver operation

Simply put, battery-saver features automatically switch the pager's receiver on and off to strictly limit the time the pager is "on," thereby conserving battery life. In the POCSAG format, the battery-saver idea is carried one step further by using *time division* to restrict receiver operation to the portion of a paging transmission that contains paging information. The use of time division further limits receiver "on" time.

Thus, a typical POCSAG pager has two modes of operation: the battery-saver (mode 1) and address-search (mode 2 or lock mode). Time division is employed in the address-search mode.

• *Battery-saver mode*—With a typical "on" duty cycle of 6% to 7%, the battery-saver mode is the pager's highest efficiency mode. Figure 1 on page 46 replicates a duty-cycle illustration found in most pager service manuals.

For a more accurate calculation, the battery-saver current-draw duty cycle may be measured directly, using the circuit shown in Figure 2 on page 48. The circuit is a common operational amplifier calibrated to convert total pager current into a voltage waveform. The voltage waveform may be displayed and measured on a storage oscilloscope, and the results may be plotted as required.

During the brief "on" time pulses, the pager is looking for the start signal (POCSAG preamble) to switch the unit from its battery-saver mode to its address-search mode.

The *transition* between the battery-saver mode and address-search mode is important in regard to current drain because, once the preamble is detected, the pager's RF section must remain on until the synchronization code is detected. Depending on exactly when the

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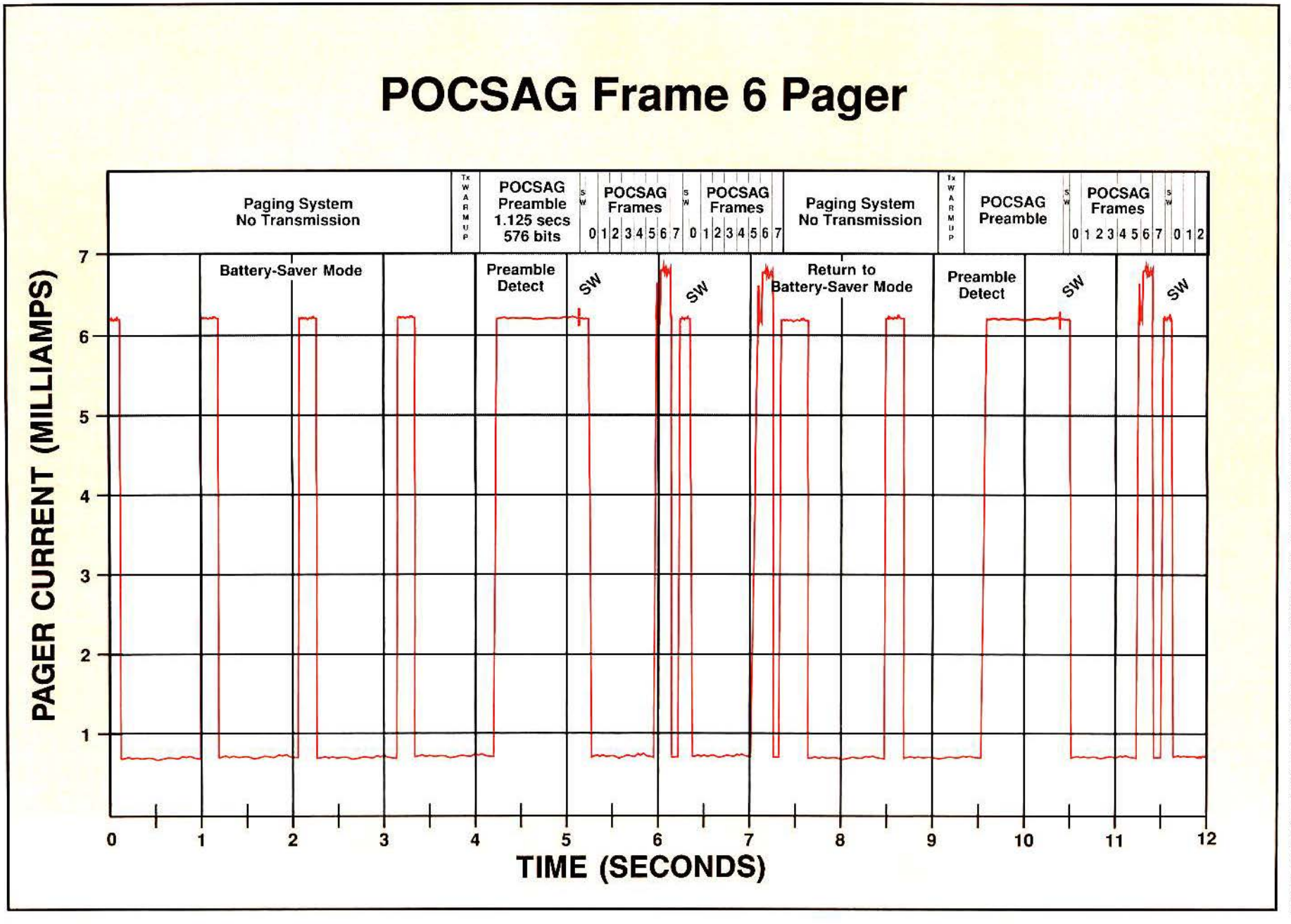

Figure 1. With a typical 'on' duty cycle of 6% to 7%, the battery-saver mode is the pager's highest efficiency mode. This diagram replicates the duty-cycle illustration found in most pager service manuals.

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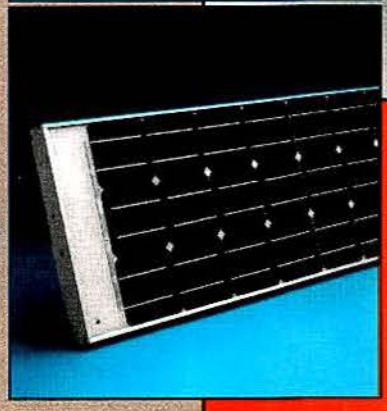

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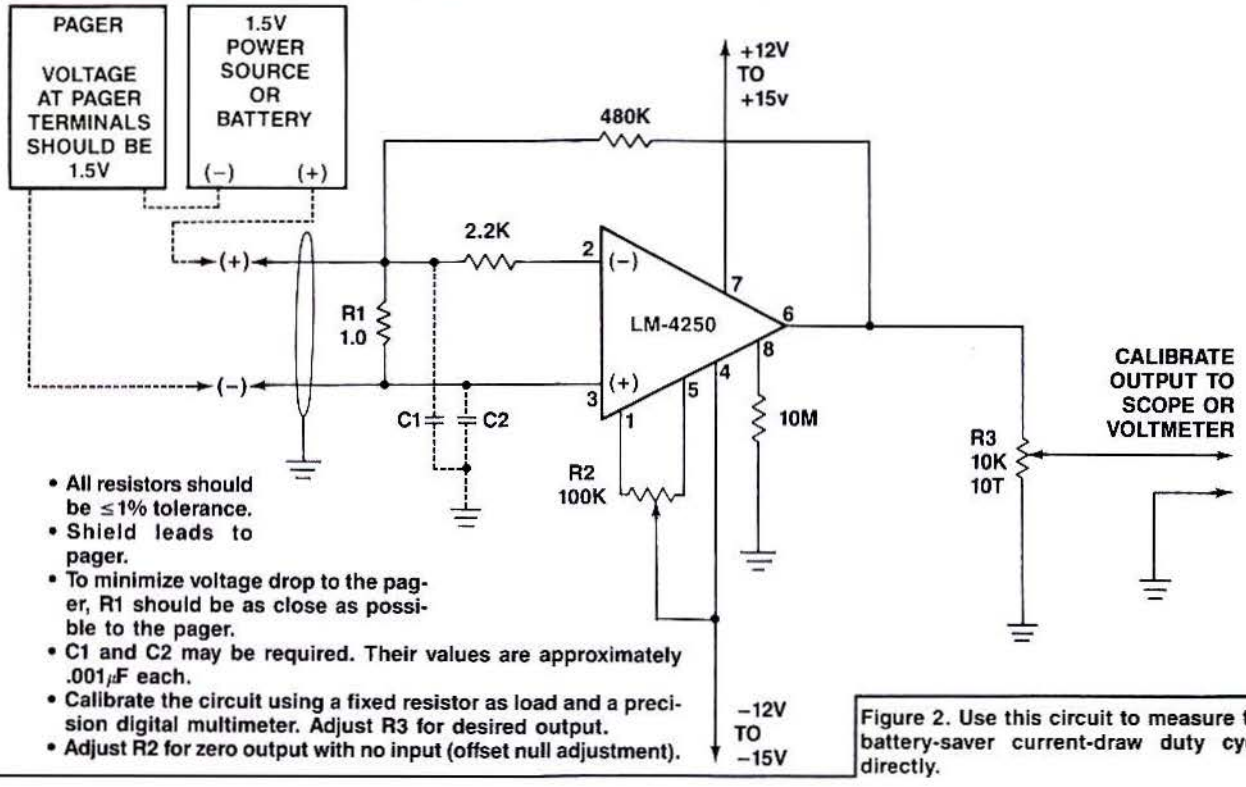

Figure 2. Use this circuit to measure the battery-saver current-draw duty cycle directly.

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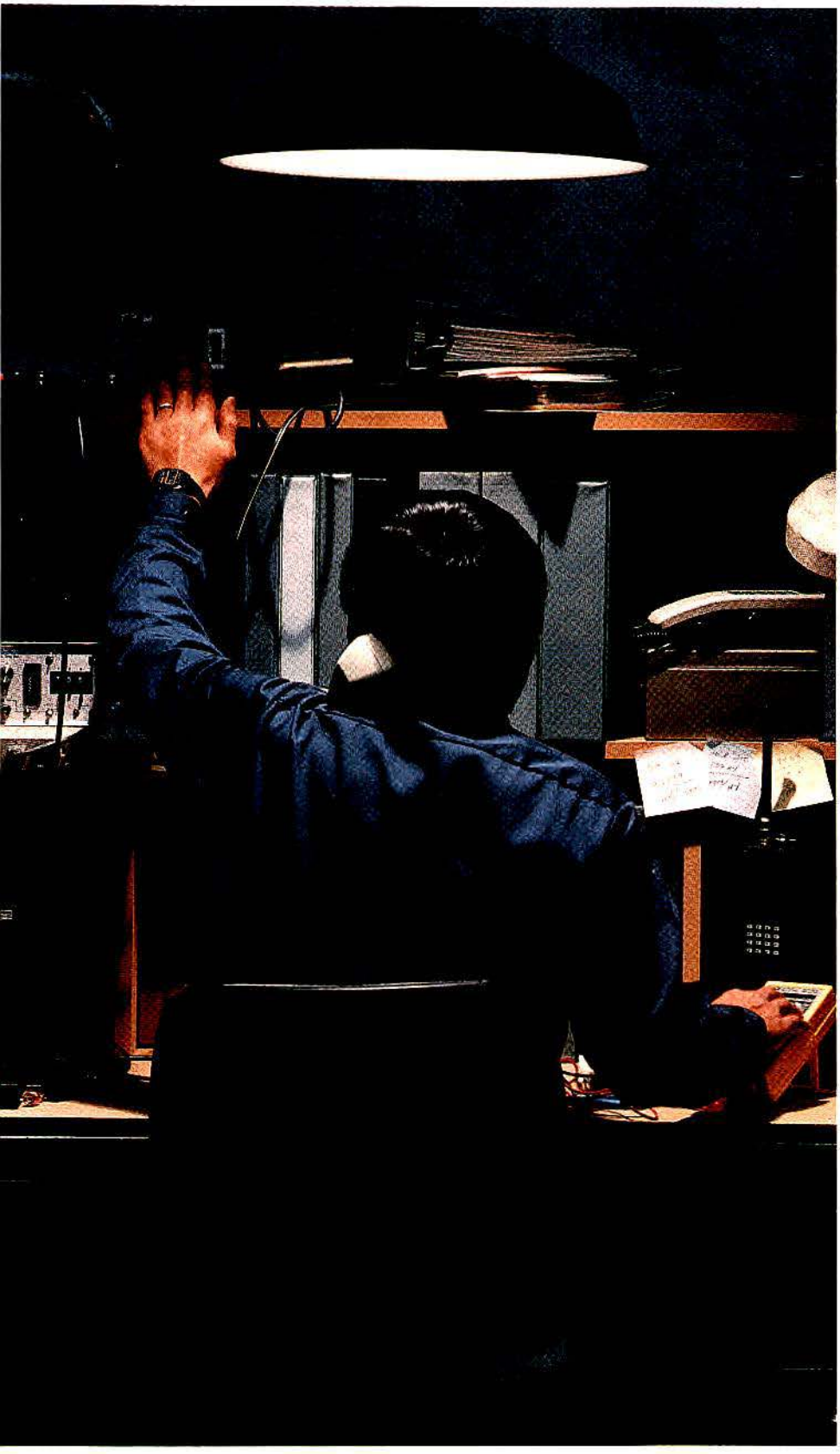

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preamble first is detected, the pager "on time" could be extended for as long as 1.125 seconds, the length of the POCSAG preamble. This time is highly significant compared to the battery-saver and address-search modes, which have much shorter "on" times. See Figure 1.

• *Address-search mode*—To understand pager operation in the address-search mode requires a basic familiarity with the POCSAG format. Figure 1 includes a diagram of a single POCSAG transmission. Note that it is composed of three major parts: the preamble, the synchronization code and the batch, consisting of eight frames of two POCSAG codewords each. Additional batches can be transmitted without an additional preamble by transmitting a synchronization code after the first batch and continuing.

Each POCSAG pager is assigned to one of the eight POCSAG frames. In other words, every pager searches within its assigned frame for paging information. In address-search mode, the POCSAG pager must turn on for every synchronization code transmitted. It must turn on during its assigned frame, too, once for each batch transmitted. The sync code and frame search action give an "on" time duty cycle of 17.6%, which is significantly higher than the battery-saver mode duty cycle.

Battery life calculations

Once the digital pager's operating modes are identified, the next step is to calculate the *overall average pager current draw*, which accounts for all pager operation factors affecting battery life. These factors include all duty cycles and the time the unit operates in each duty

POCSAG

POCSAG stands for Post Office Code Standardisation Advisory Group, the name of an international group of engineers whose first meeting in 1976 was chaired by the British Post Office. After a series of meetings, the engineers reached their goal: the development of a mutually acceptable code for wide-area paging. Initially, the code was named after the group.

In 1981, the code was accepted by the International Radio Consultative Committee (known by its French abbreviation, CCIR) as the recommended Radiopaging Code No. 1.

CCIR acceptance has given rise to other designations for POCSAG, including RPC1 and CCIR No. 1.

Telocator, a U.S. trade association that represents radiopaging, mobile telephone and personal communications services system operators, calls the code POCSAG.

Among pager manufacturers, Motorola calls the code POCSAG (CCIR code #1); NEC calls it POCSAG; and Panasonic uses POCSAG and CCIR-RPC1 interchangeably as names for the code.

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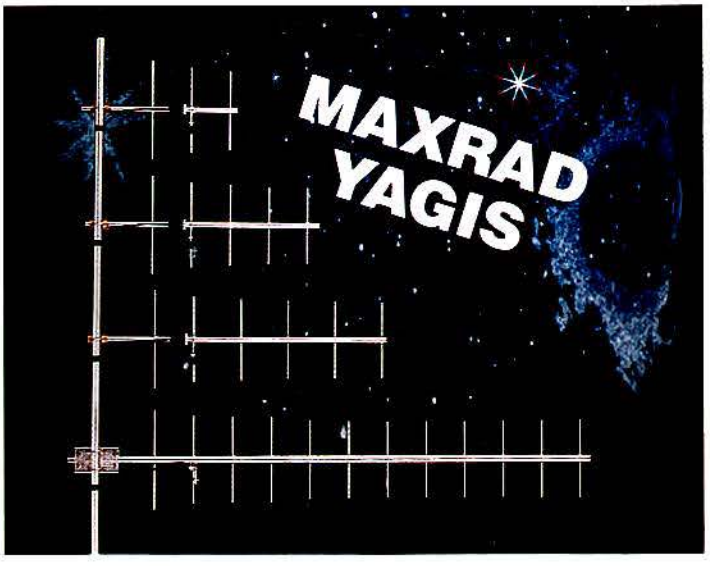

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Table of calculations

Overall average current draw calculation summary

(1) Full 'on' current duty cycles averaged over 24 hours

([(18 hours × off-peak duty cycle) + (6 hours × peak duty cycle)] ÷ 24 hours) × (full on current draw) +

(2) Full 'off' current duty cycles averaged over 24 hours

([(18 hours × off-peak duty cycle) + (6 hours × peak duty cycle)] ÷ 24 hours) × (full off current draw) +

(3) Preamble detection current draw averaged over 24 hours

[(number of transmitted preambles × preamble detection time in hours) ÷ 24 hours] × (full on current) +

(4) Vibrator current draw

(vibrator current draw × vibrator on time in hours) ÷ 24 hours =

(5) Overall current draw averaged over 24 hours

Numeric calculations

(1) ([(18 × 0.4 × 0.176) + (18 × 0.6 × 0.065) + (6 × 0.72 × 0.176) + (6 × 0.28 × 0.065)] ÷ 24) × 6 +

(2) ([(18 × 0.4 × 0.824) + (18 × 0.6 × 0.935) + (6 × 0.72 × 0.824) + (6 × 0.28 × 0.935)] ÷ 24) × 6 +

(3) ([(933.3 × 0.00015625) ÷ 24] × 6) +

(4) (86.6 × 0.011) ÷ 24 =

(5) 1.315mA

Note 1. Preamble detection time and vibrator alert on time, normally thought of in terms of *seconds*, have been converted to hours for purposes of averaging over 24 *hours*.

Note 2. 86.6mA is the actual vibrator current measured in the sample used for test purposes.

(continued on page 54)

cycle throughout the day in peak and off-peak hours.

The average figure includes the small current draw that happens during the duty-cycle period when the RF section is turned off. It includes current draw for typical vibrator alert use because the vibrator is the most popular alert option. A vibrator motor draws a lot of current.

• *Duty cycle figures*—How much time the pager spends in each operating mode depends on the number of POCSAG batches sent per hour, the system efficiency, the number of subscribers on the system, the POCSAG encoder batch timing and the call rate during peak and off-peak hours. Unless these facts are known, assume conditions that closely match actual system operation.

For the purposes of a sample calculation, the following assumptions are made:

System conditions:
50,000 subscribers
0.18 peak-hour calling rate
0.10 off-peak calling rate
Minimum encoder batch timer setting
Six peak hours per day

Batching conditions:
Three batches per POCSAG transmission
15 10-digit calls in each transmission

In actual practice, the number of batches in each transmission and the number of calls in each batch varies considerably. An ideal set of conditions is assumed to simplify the calculation.

Using the conditions as defined, calculate the time the pager spends in each operating mode as follows:

Peak-hour mode calculation:
50,000 subscribers × 0.18 peak-hour calling rate = 9,000 calls per hour.

9,000 calls per hour ÷ 15 calls per transmission = 600 transmissions per hour.

600 transmissions per hour × 4.3125 seconds (the time required for a single POCSAG transmission as given above) = 43.125 minutes.

Peak-hour summary: Given the transmission time above, during peak hour the pager operates in the address-search mode (mode 2) for approximately 0.72 hour and in the battery-saver mode

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(continued from page 52)

Battery life summary

(1) Battery capacity (using Duracell AA-MN1500): 2,450mAh

(2) Usable battery capacity (assuming 1.1V cutoff: approximately 70%)

(3) Hours of pager operation = (mAh × 0.7) ÷ average pager current draw

(4) Days of pager operation = hours ÷ 24

(5) Months of operation = days ÷ 30

Numeric calculations

(1) 2,450 mAh ×

(2) 0.7 = 1,715

(3) 1,715 ÷ 1.315mA = 1,304 hours

(4) 1,304 ÷ 24 = 54 days

(5) 54 ÷ 30 = 1.8 months battery life (using the assumed system conditions)

Note 3: In actual practice, the battery life of the R3D4-4C pager is closer to one month than 1.8 months. The difference can be attributed to many factors, including efficiency, number of subscribers and the calling rate of the actual system.

(mode 1) for approximately 0.28 hour.

Off-peak hour mode calculation:

50,000 subscribers × 0.10 off-peak calling rate = 5,000 calls per hour.

5,000 calls per hour ÷ 15 calls per transmission = 333.3 transmissions per hour.

333.3 transmissions per hour × 4.3125 seconds (the time required for a single POCSAG transmission) = 23.96 minutes.

Off-peak hour summary: During off-peak hours, the pager operates in the address-search mode (mode 2) for approximately 0.4 hour and in the battery-saver mode (mode 1) for approximately 0.6 hour.

The peak hour and off-peak hour calculations are necessary because they reveal *for what fraction of each peak and off-peak hour the pager in question is in each of the two duty-cycle modes.* Because the number of peak and off-peak hours are known (or assumed, as in this example), it is possible to calculate overall average current draw by accounting for the pager duty cycles and by averaging them over a 24-hour period.

Calculation of secondary factors: Using the initial calculations above, the stage is set for putting together all the numbers for the overall average current draw figures. But the initial calculations overlook important secondary factors that contribute extensively to average current draw. Here are the secondary factor calculations that are used to compute the final average.

Off-time current draw:

The RF off-time current typically is quite small, yet its effect is significant because the pager receiver remains "off" for the largest percentage of overall operating time. The off-time current draw figures are generated as follows:

Mode 1 off-time current draw
= 1 − (mode 1 on-time duty-cycle ratio) × (full off-current)
= 1 − 0.065 × (full off-current)
= 0.935 × (full off-current)

Mode 2 off-time current draw
= 1 − (mode 2 on-time duty-cycle ratio) × (full off-current)
= 1 − 0.176 × (full off-current)
= 0.824 × (full off-current)

It clearly can be seen why the off-current is an important factor. The pager operates in this mode between 93.5% (mode 1) and 82.4% (mode 2) of the time.

• *Preamble detect*—As shown in Figure 1, preamble detection, also known as transition mode current draw, is significant because of the comparatively long period in which the pager may remain in the "on" mode. Depending on when a preamble initially is detected, a pager may remain on between a maximum of 1.125 seconds and a minimum of about 100 milliseconds.

Assuming that the point at which the preamble initially is detected is random, it can be reasoned that, on the average, the preamble is detected at the halfway point each time. The halfway point represents a pager "on" time of 0.5625 seconds for each preamble transmitted. The preamble detection current draw, therefore, is averaged into overall current draw as follows:

[(Total number of preambles transmitted) × preamble detect "on" time in hours)] ÷ 24 hours × (full on-current).

The number of preambles is defined by the conditions set for the example. The number of preambles transmitted in a 24-hour period equals the total number of transmissions, including peak and off-peak hours because each transmission begins with a single preamble.

• *Vibrator alert current draw*—Most pagers on the market today are ordered with the vibrator alert function. Because the vibrator option uses a high-current motor, current drawn during an alert must be figured into the overall average. This figuring can be done by assuming a certain number of calls received per day, the length of the vibrator alert and the vibrator current draw. For purposes of this example, a reasonable figure in-

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cludes five calls per day, an eight-second vibrator alert if the user does not reset the pager by then and 90mA current for the R3D4-4C pager.

A word of caution is in order concerning battery milliamp-hour capacity. Usually, milliamp-hour capacity in the case of an AA battery is quoted in terms of useful battery capacity from 1.5V (nominal AA battery voltage) to 0.8V. But a pager does not operates successfully at less than 1V, which means only about 70% of the battery's rated capacity is useful. If this factor is not taken into account, battery life calculations will be in error. See Table 1 on page 52 for the final, overall battery life calculation.

What it all means

Battery life estimates are complex as manufacturers indicate. In addition to this basic fact, calculations imply the following general principles:

Good system efficiency improves battery life. For instance, fewer transmitted preambles means less overall current draw for the pager. Transmitting fewer preambles translates into sending fewer transmissions over the system. Reductions can be made by using longer paging transmissions and paying careful attention to code assignment, among other methods.

Users must be educated on proper pager use. Vibrator current draw can be decreased if the vibrator alert is reset as soon as possible when a call is received. Turning the pager off when not in use helps. So does refraining from playing with the pager by turning on the vibrator or other alert features, checking the display and switching on the backlight when there is no need, for example.

Though the calculations may seem complicated, they show that the average pager is designed for a battery life of four to six weeks or more. Although four to six weeks of battery life is the target, every pager performs differently because of the complexities inherent in its battery-saver operation.

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Choosing proper frequencies for private carrier paging

Everyone wanted 152.480MHz when it was the VHF frequency with the highest power. Now that the power limit has been raised for 157.740MHz, its popularity will rise. But lower-power alternatives may be far better.

By Raymond C. Trott, P.E.

One reason many paging system operators get into the private carrier paging (PCP) business is that few frequencies are available for radio common carrier (RCC) paging. Common carriers have the advantage of exclusive frequencies they do not have to share with any other licensees in their areas. But there are some advantages to being a PCP operator, such as freedom from state regulation and a comparatively fast licensing process.

Invariably, potential PCP system operators ask, "What is the best frequency?" Some who do their homework ask: "What about 152.480MHz? It seems to provide much more coverage with fewer transmitters because of the higher power and because it is in the 150MHz VHF highband." And they are right.

But the problem is that everybody else thinks the same way. Potential license applicants look for areas where 152.480MHz is available and find that there is too much activity on it already.

Many of them do not realize that other available frequencies offer satisfactory coverage. These other frequencies, in many areas, are not congested.

Allocated paging frequencies

Table 1 above shows the number of private and common carrier paging frequency allocations. The fact that a frequency is allocated does not necessarily mean it is available.

Trott is president of Raymond C. Trott Consulting Engineers, Irving, TX. He is a fellow and director of the Radio Club of America; a member of IEEE and of its Vehicular Technology Society's board of governors; and a member of *MRT's* editorial advisory board.

Table 1—The number of frequency allocations, by band, for common and private carrier paging.

BAND	COMMON CARRIER	PRIVATE CARRIER
Lowband	32	0
Highband	22	4
UHF	26	9
900MHz	40	20
TOTAL	120	33

- *Lowband VHF*—In the VHF lowband, 30MHz to 50MHz band, RCCs have 32 exclusive channels, and private carriers have none. That is not so bad, actually, because from a technical perspective, lowband VHF is the least desirable band for paging systems—although the equipment may be the least expensive for that band compared to other bands.
- *Highband VHF*—In the 150MHz VHF highband, RCCs have 22 channels available. Eighteen actually are channel pairs originally used for mobile telephone. One frequency in a pair is for the base transmitter and the other is for mobile transmitters. Until a few years ago, FCC rules permitted paging on these channels, but only on a secondary basis. Presently, RCCs may offer mobile telephone and paging service on a primary basis on these 22 channels.

For an RCC to operate a paging transmitter on the mobile transmitter frequencies, the FCC requires a detailed interference analysis.

The mobile frequencies may be used for remote control purposes, too.

For private carriers, the VHF highband has only four frequencies allocated for paging only.

- *UHF*—In the 450MHz UHF band, 26 frequency pairs are allocated to RCCs. As is the case with the VHF channel pairs, the base station frequencies are available for paging use and, with a detailed interference analysis, so are the mobile channels. Similarly, the mobile channels can be used for control.

Private carriers have nine UHF channels.

- *900MHz*—The FCC has allocated 40 RCC paging channels in the 931MHz band. Three of them are set aside for nationwide paging.

Forty channels are allocated for licensees eligible to apply under Part 90 of the FCC rules. Twenty of those channels are reserved for use by businesses that operate paging systems for their own use. These businesses may not sell paging service to others.

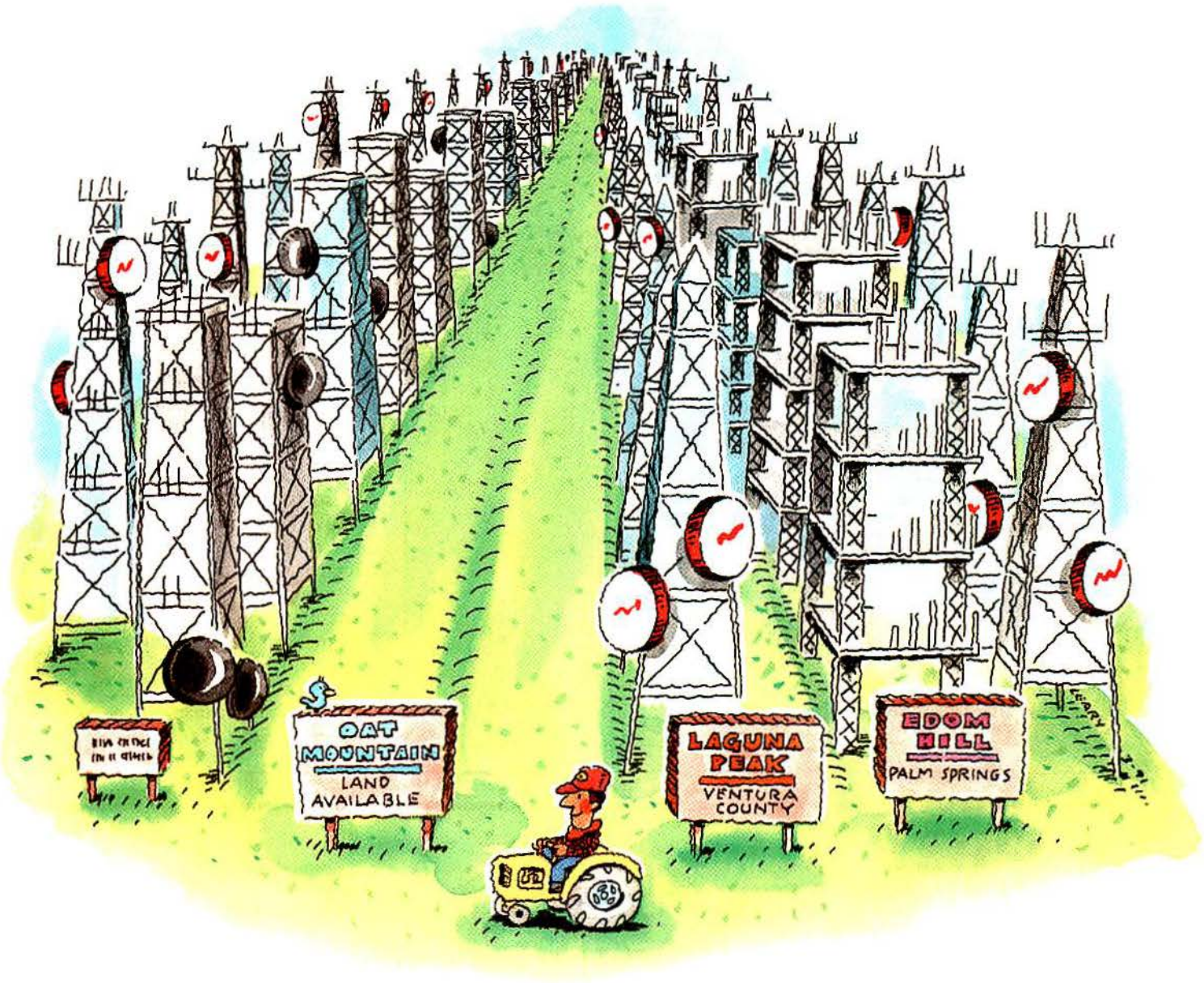
The other 20 channels are available for PCP system operators. Table 1 shows 20 private carrier frequencies at 900MHz.

Private carriers have 20 channels in the 929MHz band. If and when the 20 channels allocated for individual businesses are full, such businesses may apply to use PCP frequencies, too.

Summarizing, 120 frequencies are available for exclusive use by RCC licensees for paging systems. Private carrier licensees have 33 shared frequencies allocated to them.

Frequency comparisons

The most popular PCP frequency has



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been 152.480MHz because, until August 1990, it was the VHF PCP frequency with the highest power limit—350W transmitter output. In August 1990, the FCC raised the power limit on 157.740MHz from 75W to 350W, giving PCP operators two high-power VHF frequencies.

On frequencies below 900MHz, power levels are specified as transmitter output, not effective radiated power (ERP). At VHF, private carrier systems may use a high ERP, well beyond 500W, through the use of high-gain antennas. On the other hand, RCCs are limited in most cases to 500W ERP, provided the antenna height is less than 500 feet above average terrain (AAT).

Here are some examples of typical ERP levels for private carrier frequencies (Table 2 at the right):

On 152.480MHz, with 350W transmitter output, 180 feet of feedline and a 6dB omnidirectional antenna, the practical ERP limit is 1,000W. With a side-mounted antenna, a directional pattern and 10dB gain in the direction of maximum power, the ERP is about 2,100W.

Table 2—Available private carrier paging frequencies and their power limits.

FREQUENCY IN MHz	TRANSMITTER POWER LIMIT IN WATTS	PRACTICAL ERP LIMIT
152.480	350	1,000
157.740	350	1,000
154.625	20	70
158.460	20	70
462.750	350 (250)	2,800 (2,000)
462.925	350 (250)	2,800 (2,000)
465.000	35	280
929.0125	—	1,000*
929.9875	—	1,000

*maximum 1,000 feet above average terrain.

On 154.740MHz, with 75W transmitter output, 180 feet of feedline and a 6dB omnidirectional antenna, the practical ERP limit is 275W. The 75W limit has been raised to 350W; 75W transmitters are in common use in systems built before the power increase.

These ERP figures are reduced when more feedline, lossier feedline or both are used, and when isolators, cavities and other lossy devices are inserted between the transmitter and the antenna.

Many system operators use side-mount antennas to boost the gain above 6dB in some directions. An increase to 10dB is common. In the collinear directional mode, as much as 12dB can be achieved. That much gain increases the ERP significantly.

Even private carrier systems with 75W transmitters are not necessarily at a power disadvantage compared to RCCs. For example, an RCC system in Dallas uses side-mounted antennas with so much gain that its transmitter power

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had to be reduced to 50W to keep the ERP down to the 500W limit that applies to RCCs.

The other two private carrier VHF frequencies have low power limits that make them usable, in many cases, only for a restricted coverage area, such as in-building-type coverage. The ERP that can be achieved with a 20W transmitter does not amount to much.

VHF high-power penalties

New license applications are filed by those looking to enter the PCP business and by current operators who have been fortunate to fill their present frequencies and who seek more channels for expansion.

Although the 350W frequencies, 152.480MHz and 157.740MHz, are highly appealing, you should take a close look at what you may be getting into on those frequencies. They may penalize you in the long run.

Coordinating new 350W systems on these frequencies may require extra work. The FCC-designated frequency coordinator, the National Association of Business and Educational Radio (NABER), requires the submission of field data that show actual loading. Unless NABER approves the additional loading your proposal represents, the FCC may not grant your application.

Surveys of many cities have revealed several UHF channels with little present activity.

You would be wise to consider a UHF frequency. A UHF system may require more transmitter sites than a VHF system to cover the same area. But the coverage is highly reliable. Moreover, you are much more likely to find a frequency with no co-channel systems—though nothing prevents future systems from being built on the frequency.

Surveys of many cities have revealed several UHF channels with little present activity. As late as 1989, two UHF channels were unoccupied in Chicago, an area where one would think all the channels would be in use.

FCC rules for UHF PCP frequencies allow 350W transmitter output, although 350W UHF transmitters have been hard to find. As off-the-shelf items, 250W transmitters are more common. With 10dB omnidirectional antenna gain, a practical ERP level of 2,000W may be achieved—more, with higher-gain, directional antennas.

That much power is sufficient for adequate coverage of large urban areas. For example, the Dallas-Ft. Worth area is covered by a 450MHz system that uses two 250W transmitter sites with more than 2,000W ERP power levels. The system has no co-channel neighbors, in part because the system is so heavily loaded it has led other applicants to use other available frequencies.

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One of the allocated UHF frequencies has a 35W transmitter output limit. It is ideal for covering a small area. Because of its low power limit, the frequency has not been popular. Thus, it may not be available in your area.

900MHz

With respect to power limits, the FCC treats the 900MHz frequencies differently from channels below 900MHz. Although a transmitter power output limit appears in the rules somewhere, it is of little practical consequence compared to the ERP limit of 1,000W at 1,000 feet AAT. This limit places PCP systems on a relatively equal power level with RCCs. Still, in this band as in the others, RCCs have exclusive frequency assignments, whereas PCP frequencies must be shared.

Fortunately, a frequency search is likely to reveal one or more 900MHz PCP channels not being used in a given area. For PCP system operators who want to build regional systems that use the same frequency in different areas, the 900MHz band offers the best chance for finding a suitable frequency.

Fortunately, a frequency search is likely to reveal one or more 900MHz PCP channels not being used in a given area.

220MHz band

NABER has asked the FCC to assign four channels in the 220MHz band for private carrier paging. But do not rush out to file an application or to buy equipment. Approval of the request is far from assured, and final action on the request may be months or years away.

Future power increases

The FCC's grant of increased transmitter power output on 157.740MHz was somewhat unexpected because the commission previously had turned down an identical request. It just goes to show that what is not possible today may be possible in the future, but no one knows for sure exactly when.

Opposition to VHF and UHF PCP power increases stems from possible interference to two-way radio users on adjacent channels.

Even without power increases, systems can be configured to use current power levels without too much trouble. The use of low-power channels actually may work to an operator's advantage in some cases because the perceived "undesirability" of the frequencies may leave them free of co-channel users.

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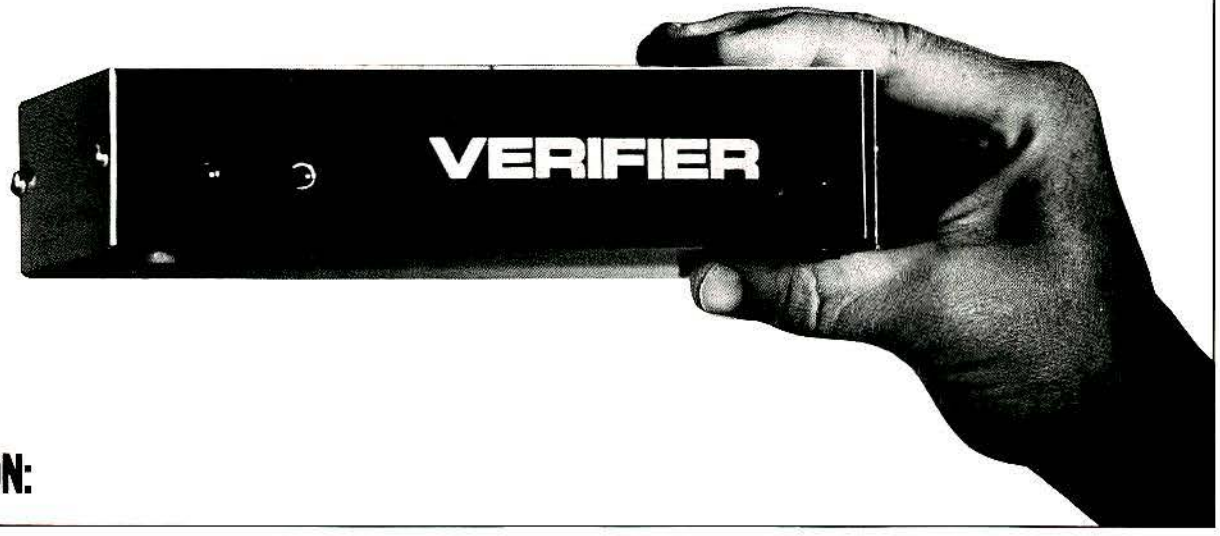

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Circle (57) on Fast Facts Card

NovAtel delves into infrared technology

NovAtel Carcom, Calgary, Alberta, has eliminated the coil cord from a cellular mobile unit handset with the use of infrared technology. The infrared handset operates from a line-of-sight distance from 10 feet to 30 feet outside a vehicle.

BellSouth buys Graphic; Ericsson purchases SCE

BellSouth is expected to close on its acquisition of Graphic Scanning next month, obtaining 32.4 million shares. Graphic Scanning operates 330,000 pagers in 21 markets in the United States, and the purchase of Graphic increases BellSouth's domestic pagers to 1 million.

Spectrum Communications & Electronics, Hicksville, NY, Graphic Scanning's paging and voice mail manufacturing subsidiary, will be purchased by LM Ericsson for $6.5 million.

Mobile satellite groups choose bird builders

American Mobile Satellite and Telesat Mobile have chosen Hughes Aircraft and Spar Aerospace to build their mobile satellites. Hughes will supply the spacecraft bus, and Spar will supply the communications payload to both companies.

Firm targets market data, spectrum acquisition

Mobile communications market research, spectrum acquisition and business development are functions of newly formed Spectrum Resources, Falls Church, VA. The company has been established by A.C. Miller, former vice president of American Mobile Systems. The company is at 307 Buxton Road, Falls Church, VA 22046; telephone 703-533-1312.

Wyant McAvoy renews Comm/Sure protection

Wyant McAvoy Insurance Agency, Fresno, CA, has renewed with Comm/Sure for mobile communications equipment loss and damage protection. Comm/Sure offers a non-deductible repair or replacement for most causes of loss, an after-warranty support service and a guaranteed next-day claim settlement service. Wyant McAvoy and Comm/Sure may be reached at 800-344-7391.

Telocator offers pagers at a reduced rate

Telocator has established a group purchase plan that extends reduced prices for pagers to its membership. Dial Page, NEC, Panasonic, International Telecom Systems and Shinwa Communications of America are participating in the program.

Telocator, a Washington, DC-based trade association representing mobile telephony and paging interests, said prices quoted by the participating manufacturers were well below what small carriers have been quoted in the past.

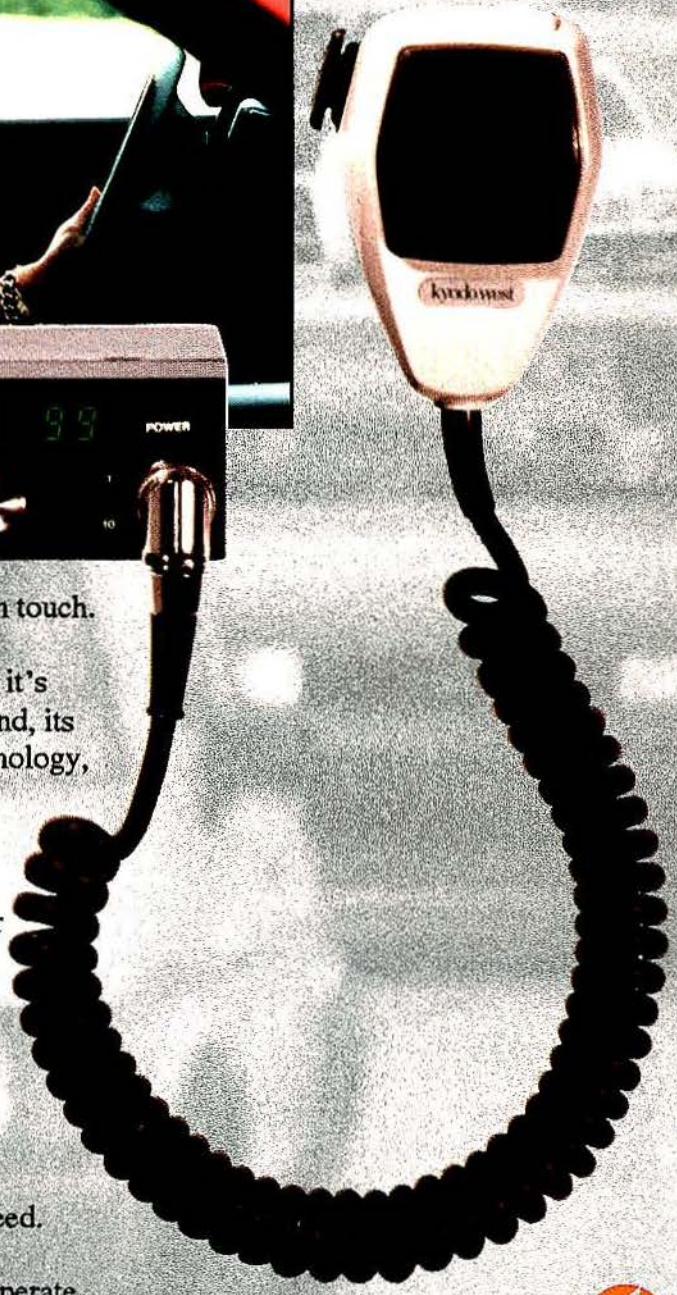
Telocator will process the orders from its membership and send them on to the manufacturers. The pagers will be shipped directly from the manufacturers to the carriers, so the trade association will not keep an inventory.

Texas college offers land mobile training

Texas State Technical Institute in Waco offers curriculum on land mobile communications. The college provides a three-month training session that includes information on hand-held radios, base stations and repeater systems, trunking and cellular telephones. After completion of the training program, participants receive a land mobile technician endorsement.

Courses may be substituted to meet the needs of a particular company, and participants can take additional courses if necessary. For information on the program, telephone Davis Matteson at 817-799-3611, extension 2943.

PROVEN PERFORMANCE



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Philips Telecom closes pager sales office

Philips Telecom has closed its U.S. office in Maitland, FL, but continues to manufacture pagers in Cambridge, England, for the European market. The withdrawal from the U.S. market has left some of its employees jobless, and others have secured new positions.

Philips Telecom general manager Edward Mathieu leads Sigtone's U.S. operation as vice president and general manager. Sigtone recently moved to Maitland from Huntington Beach, CA. According to Sigtone, Florida is closer to South American markets than California, and the company wants to target these markets in the future.

CNW unveils warranty program

Communications Northwest (CNW), Portland, has incorporated a five-year warranty program for the two-way radio market. The "Today's Solution to Tomorrow's Problem" program is backed by Lloyds of London and includes:

- no deductible.
- no limit on the number of repairs.
- nationwide service.
- a toll-free number for assistance.

Equipment backed by the warranty program must be purchased new, and must have a minimum 90-day labor and a one-year parts original factory warranty.

Repairs can be completed by the dealer who sold the warranty. Reimbursements are made within 30 working days.

Harris RF receives Army Blue Ribbon title

Harris RF Communications Group, Rochester, NY, has received the Army Communications-Electronics Command's Blue Ribbon Contractor designation for dependable quality and delivery.

Valmont appoints rep

Valmont Industries, Valley, NE, has named Montague-Murray as its representative for New England. The rep firm may be reached at 617-331-4880.

Uniden passes vocoder test

Uniden America, Ft. Worth, TX, has passed the vocoder test for its speech decoders under the second gate in CTIA's lockdown test plan. The vocoder test mandates that the mobile and system vendors test their speech decoders against a decoder provided by Motorola, Schaumburg, IL. The CTIA test includes four tests of gates that must be passed to be included in the lockdown matrix. Uniden has been developing digital signal processor equipment for digital cellular mobile telephone since 1989.

Decibel designates factory warehouses

Decibel Products, Dallas, has appointed two additional factory-authorized warehouses to join 11 other U.S. warehouses and six international warehouses that stock Decibel products.

The new warehouses are Communications Associates, 305 N. Republic Ave., Joliet, IL 60435; and Communications Express, P.O. Box 1158, Clifton, NJ 07014.

Comcast wants to link cellular, cable, PCS

Comcast has asked the FCC for authority to experiment with personal communications services (PCS) technology in five markets where it provides cable TV service. The Philadelphia company wants to interconnect PCS signals with a cellular telephone network and a cable distribution system, as well as testing the signals with cable systems only.

CA trucking group to add cellular phone service

The California Trucking Association plans to purchase cellular telephones and service from PacTel Cellular, Irvine, CA, for use by its members. The group estimates the arrangement could net 20,000 cellular phones sales. The association has 2,500 members statewide, and its members will be able to use voice and data transmissions in their respective trucking operations with the service.

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SprintNet joins ARDIS network

US Sprint's SprintNet public data network has been connected to the ARDIS nationwide radio data network, enabling customer access to their company's mainframe computers via hand-held and portable computers with radio modems.

Mobile Mark expands with European factory

Mobile Mark, Schiller Park, IL, opened a European factory in Staffordshire, England. The manufacturer's subsidiary, Mobile Mark (Europe) Ltd., manufactures vehicular antennas for two-way and cellular markets.

Bird picks reps

Bird Electronic, Cleveland, has named two representatives:

- Tritek serves New England for sales to original equipment manufacturers, industrial and calibration laboratories, and the federal government. The rep company is at 155 Middlesex, Burlington, MA.
- Saber Associates handles Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina and Tennessee. It has offices in Melbourne, Orlando, Ft. Lauderdale and Tampa, FL; Atlanta; Huntsville, AL; and Raleigh, NC.

Cellular carrier purchases paging, SMR systems

A subsidiary of Century Communications has bought paging, SMR, IMTS, and telephone answering operations from Hendrix Electronics and Hendrix Radio Communications. Century owns or has agreed to purchase cellular telephone systems serving markets with a total population of 2,350,000. The Hendrix operations serve areas near Yuma, AZ; and Blythe, Brawley and El Centro, CA.

ISS establishes pact for backup use of uplink

ISS Engineering, Palo Alto, CA, has reached an agreement with GE American Communications for the use of GE's South Mountain uplink in Ventura County, CA, as a backup to the ISS link in case of a disaster. The company recently installed an automatic transfer backup power generator with 24-hour remote monitoring and automatic redundant switching to further ensure paging customers satellite delivery of their paging signals in the United States.

Direct Conversion moves

Direct Conversion Technique, a manufacturer of RF test equipment, has moved to 1245 Forest Ave., Des Plaines, IL 60016; phone 708-827-2280; fax 708-827-2280. The office and manufacturing facility consolidates operations, including administration, assembly and test, warehouse, and research and development.

Antenex names distributor

Antenex, Wood Dale, IL, has named Talley Electronics, Santa Fe Springs, CA, as a full distributor of its mobile and portable antenna products. Talley is at 9871 Pioneer Blvd., Santa Fe Springs, CA 90670; phone 800-221-5967. Warehouses include: Hayward, CA, 800-223-4949; San Diego, 800-869-8515; and Phoenix, 800-727-7410.

Sinclair opens southwest office

Sinclair Radio Laboratories, Tonawanda, NY, has opened a sales office and warehouse in Grand Prairie, TX. The southwest location serves Arkansas, Kansas, Louisiana, Missouri, Oklahoma and Texas.

Charles Penry is the office's area manager. The office address is 2009 108th St., Suite 905, Grand Prairie, TX 75050; phone 214-988-9966 and 800-926-7886; fax 214-641-4884.

Boston Transit contracts Safetran for signaling

The Metro Boston Transit Authority has signed a contract with Safetran Systems, Louisville, KY, for its signaling and communications system on the Everett Junction Line.

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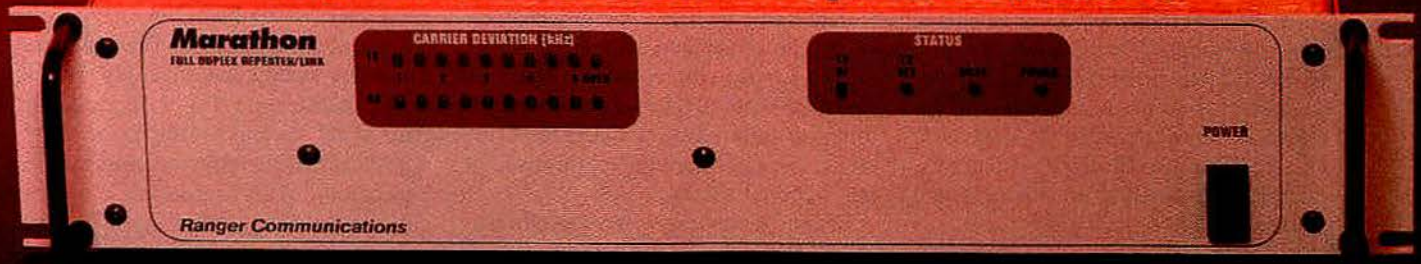

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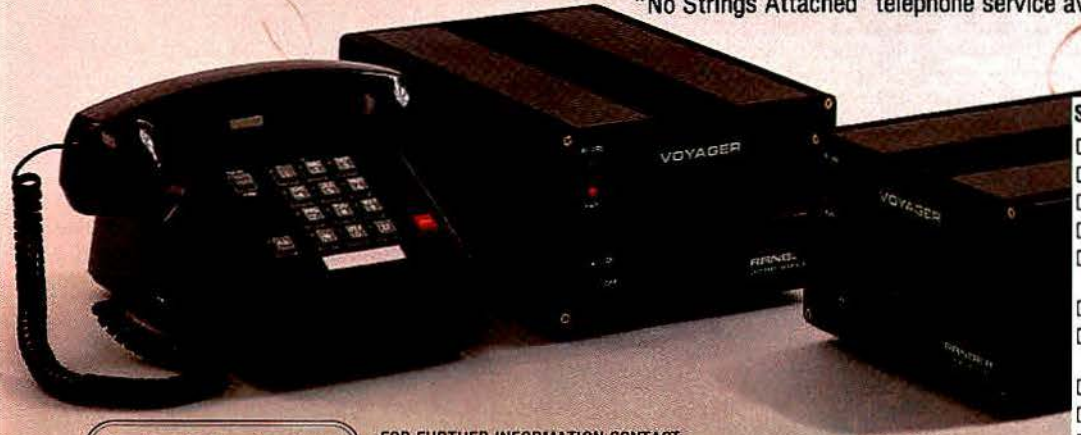

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Circle (83) on Fast Fact Card

Ambo joins ACT volunteer leadership council

Steve Ambo, the service manager at the Motorola service center in Wood River, IL, has been elected to the Association of Communications Technicians (ACT) volunteer leadership council. ACT is a membership section of the National Association of Business and Educational Radio (NABER).

Ambo said he heard about the association through Ranken Technical College in St. Louis, where he graduated in 1986. He worked there once as a nighttime substitute instructor, and he serves on the college's communications sector instructional review board.

Ranken encourages its communications students to obtain NABER certification, which Ambo did. The FCC does not want technicians to apply for the FCC license unless it is required for their work, such as for the repair of aviation and marine radio communications equipment. With Motorola Communications and many other employers requiring their land mobile radio technicians to have either a NABER certificate or an FCC license, it makes more sense for new technicians to obtain the NABER certificate.

Ambo has seen firsthand the NABER certificate's value as a basic qualification standard for hiring technicians, leading him to support the certification program. "The FCC no longer requires land mobile radio technicians to hold an FCC license," he explained, "and the NABER certificate helps to take its place. I believe in it."

He supports the association because he believes technicians need organized representation. "The FCC might not have removed the license requirement if an organization such as ACT had existed then and if it had opposed the change," he said.

Along with joining the council, Ambo has joined NABER's technician certification examination committee. The committee helps to generate and review questions included in the certification examination.

Dissatisfaction with a landscaping job he took after leaving active Navy service led Ambo to attend Ranken, where he developed his naval electronics experience into radio communications equipment service skills. Military benefits helped to pay for studies that earned him an associate degree in communications technology. Two months before graduation, he received a firm job offer from the service center where he now works. The center is owned by Dechant Electronics, a division of St. Louis Electronics. Ambo continues his studies toward a bachelor's degree at Southern Illinois University, and he handles communications assignments as a Navy reservist.

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The RPM-450 mobile radio can be dealer programmed by using "key clicks" on the hand microphone or via a PC compatible computer.*

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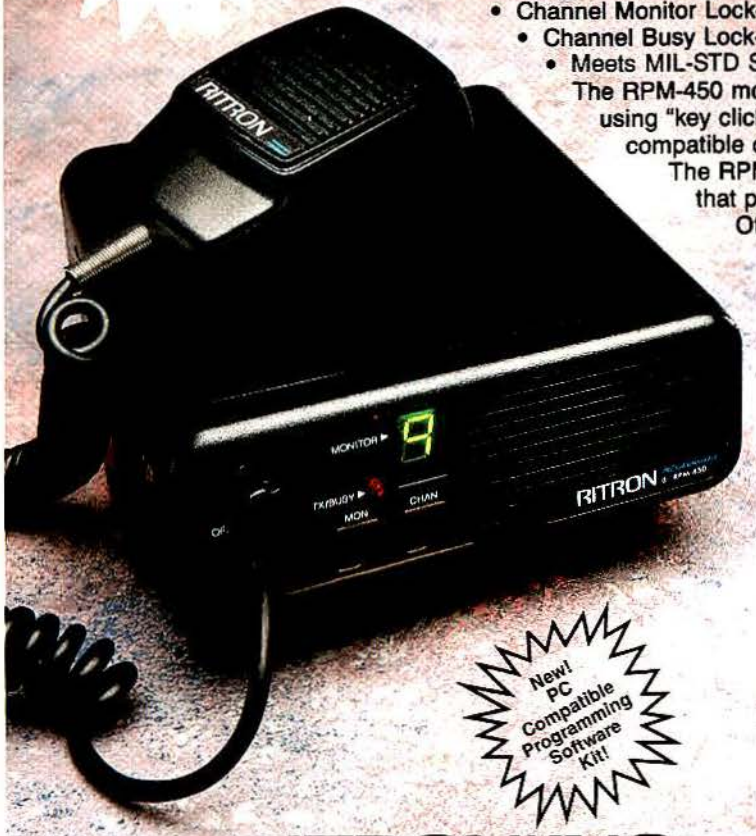

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The radio's rugged "Uni-Body" aluminum housing is virtually indestructible (actual photo: Chevy Blazer atop RPM-450).

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Six companies seek air-to-ground licenses

Six companies have applied to the FCC for licenses to offer air-to-ground telephone service on U.S. commercial airlines. GTE Airfone presently offers such service as a continuation of operations that began under an experimental, developmental license.

GTE Airfone is one of the applicants. The others are:

- In-Flight Phone, a company founded by Airfone founder John D. Goeken. Goeken was forced to resign from In-Flight Phone when a court upheld GTE Airfone's enforcement of a non-compete contract with Goeken.
- Clairtel Communications Group, a joint limited partnership of McCaw Cellular Communications and Hughes Network Systems.
- Mobile Telecommunications Technologies, a company that presently operates a nationwide paging service, SkyTel.
- American Skycell.
- Jet-Tel Group Limited Partnership, a company whose principals have interests in cellular telephone, publishing and retailing.

FCC gives amateur radio a code-free license class

The FCC has modified its Amateur Radio Service rules to offer a license whose examination requirement omits a Morse code proficiency test. Under the modified rules, current holders of Technician class licenses may retain and renew them. Current holders had to pass a five words-per-minute code test.

New applicants for a Technician license face a more comprehensive written examination and no code examination. The license conveys full amateur privileges in frequency bands above 30MHz.

FCC turns down request to quit licensing SMR users

The American SMR Network Association petition to abolish end-user licensing has been denied by the FCC. Private Radio Bureau chief Ralph Haller said information gleaned from end-user licensing is needed for spectrum management and for administering specialized mobile radio (SMR) rules.

Spectrum study may result in new frequency reserve

According to its chairman, the FCC intends to establish a radio spectrum reserve for new radio technologies. "To the extent that radio spectrum is not available to support new services and new production on the part of U.S.-based companies, their competitiveness in offshore markets will be impaired," said Alfred C. Sikes.

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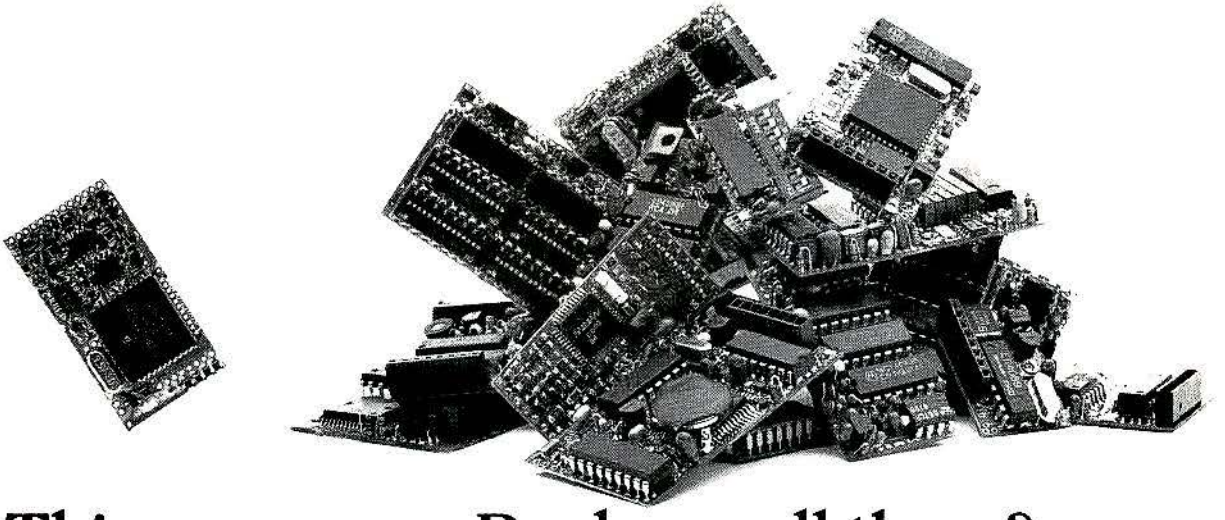

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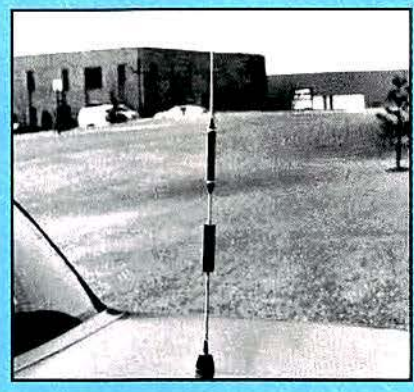
Circle (69) on Fast Facts Card

Readers' choice

Of all the new products and services in the September 1990 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

All-band scanner antenna mounts to vehicle roof, deck



Model MON-53 all-band scanner antenna is designed to enhance performance at 800MHz frequencies. The **Antenna Specialists** unit mounts to a vehicle roof or deck and comes with a 17-foot coaxial cable with an installed pin plug. Model MON-52 is a trunk-lid version; and MON-58 is a base station unit.

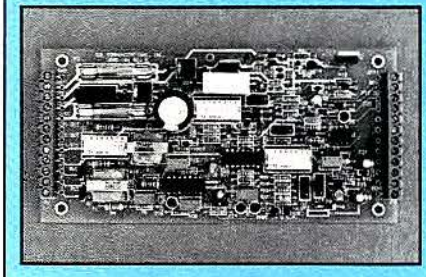
Circle (371) on Fast Fact Card

Video imaging terminal works over narrowband RF

The RF-3700-08 portable digital video imaging transmission system transmits high-resolution color images over narrowband communications channels. The **Harris** terminal can be used for color maps and documents, as well as other video images. The terminal works as part of a variety of fixed stations, mobile and portable units.

Circle (372) on Fast Fact Card

Radio adapter offers 2- or 4-wire data lines



The URAD-101 universal radio adapter from **IWL Communications** includes 2- or 4-wire voice or data lines; crossband operation; trunking; full- or half-duplex operation; relay; and repeat functions. The adapter works with most radio equipment equipped with audio in or out with or without PTT and COS.

Circle (373) on Fast Fact Card

Shop management software includes repair module

Inventory, repair orders and custom-printed tickets are features of **Pyramid Communications'** shop management software. The service management program includes 38 separate features that are grouped by functions into 14 modules. The inventory module contains a serial number list, warranty information and "parts billing" capability data. The repair orders module tracks active repair tickets and customer and shop history. The menu-driven software offers 27 pop-up help windows. A demo disk is available.

Circle (374) on Fast Fact Card

SMR software addition expands network control

Release 2.1 software for SMR networking increases options for mobile radio switching. The **AmeriCom** software includes outdial through the network, intermediate message processor and unique ID permissions functions. The outdial through the network function permits an operator to route calls to another switch before going out the PSTN. The intermediate message processor software connects the source and destination for call or data traffic. The unique ID permissions part enables switch validation for calls.

Circle (352) on Fast Fact Card

Software options enhance DID interface line

Software for **Hark Systems'** DID interface line allows DID trunks to be shared by several devices including voice mail, paging terminals and telephone answering service equipment. Routing software for redirecting calls from one device to another is included.

Circle (360) on Fast Fact Card

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Circle (70) on Fast Facts Card

Oscillator produces stable frequency standard

Model 8164 disciplined oscillator automatically corrects for aging and drift and provides a stable frequency standard. The **Spectracom** tester includes a disciplined oven-stabilized 10MHz oscillator with four outputs at 10MHz, 5MHz, 1MHz and 0.1MHz. The oscillator features continuous traceability, high stability and high accuracy.

Circle (326) on Fast Fact Card

Text compression technique creates customized manuals

Electronic texts—more than 5,000 pages or 10 megabytes of data—may be converted into small customized and portable manuals that use Reflection Technology's Private Eye miniature screen display for reviewing data. The Private Eye's image appears as a full-size screen of 25 lines of 80 characters each, which "float" in the air in front of the viewer. The method of text compression and high-speed retrieval allows the search of any word in the electronic test and performs the search in less than two seconds. The **SelecTronics** units weigh less than 12 ounces, accept ROM-based cartridges for updating materials and are available with options such as a keyboard, cursor control and a super-twist LCD screen.

Circle (251) on Fast Fact Card

UHF trunking mobiles deliver 15W or 35W power

Challenger UHF trunking mobiles with Clearchannel LTR provide either 15W or 35W RF power. The **E. F. Johnson** mobiles feature 10 systems, 10 groups and 100 channels. The LTR mobiles include system, group and dual-priority channel scan and meet military standard 810C and D.

Circle (276) on Fast Fact Card

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Circle (72) on Fast Fact Card

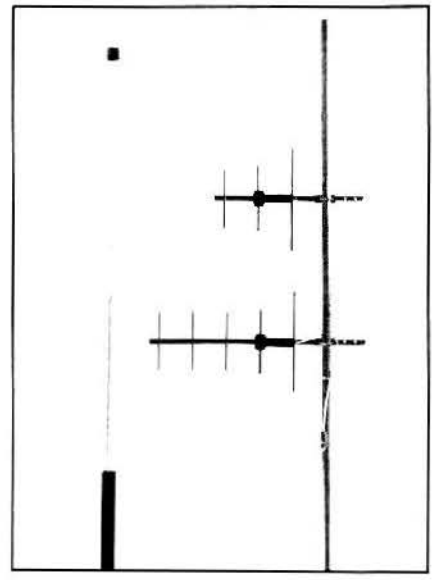
Data reroute system provides two channels

The data reroute system from **Avtec** provides two data channels with loop current or EIA RS-232C input and outputs. The system accepts data at 300bps, and operation is full duplex over a single microwave voice channel or switched telephone network.

Circle (309) on Fast Fact Card

Omni base station antennas sport copper elements

The Omni directional line of base station antennas feature copper elements, fiberglass radome and epoxy-coated aluminum mounting sleeve. The **Antek Antennas** include VHF 150MHz-to-174MHz in four models; UHF lowband 450MHz-to-470MHz; and UHF highband 806MHz-to-896MHz in two

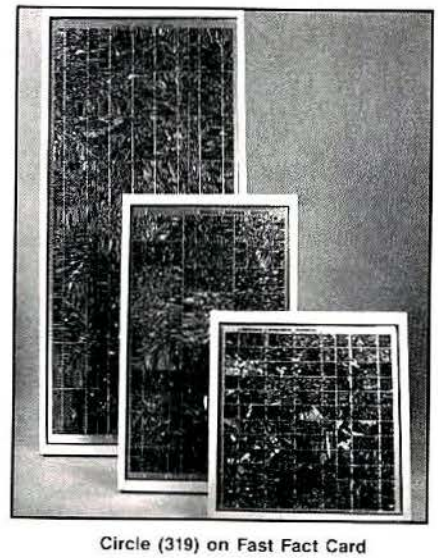


models. The Yagi line includes three- and five-element aluminum construction and frequency coverage of 806MHz to 866MHz. Termination for the Omni and Yagi antennas is a type N female connector.

Circle (303) on Fast Fact Card

Non-glass construction protects solar modules

Duravolt solar electric modules are made of a non-glass surface and aluminum backplate to resist breakage. The **Photocomm** modules come in standard sizes of 12W, 25W and 50W.



Circle (319) on Fast Fact Card

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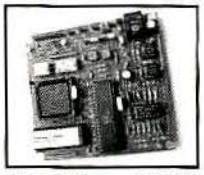

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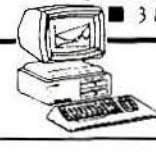

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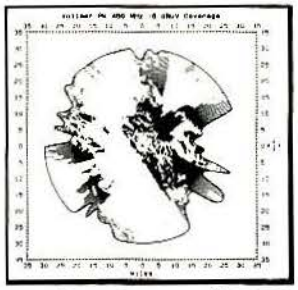

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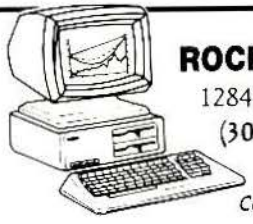

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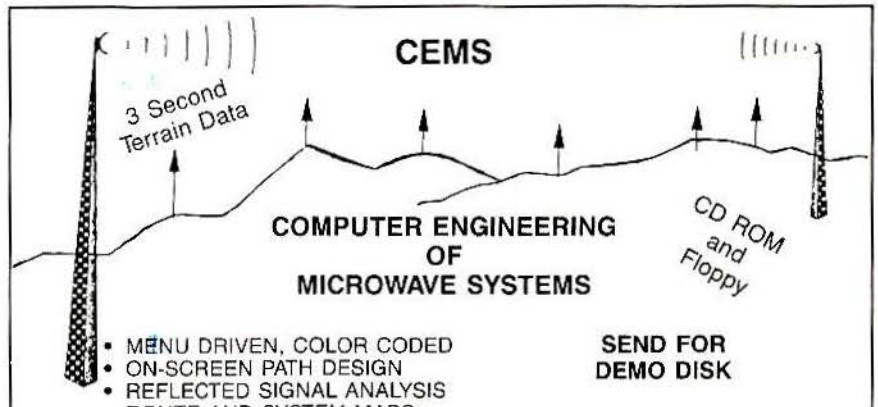

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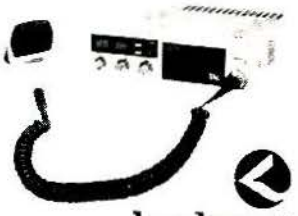

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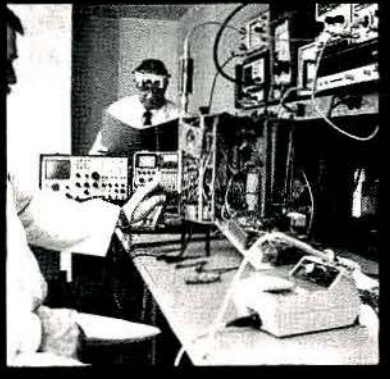

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Our PE-1000 Paging Encoder has carved a proud new chapter in simple, reliable, paging. No tools, software, or tomahawks are needed to program the user friendly features — it's done through the keyboard.

The PE-1000 is compatible with all two-tone sequential formats, and is also available in five-tone and RPC1. An internal memory, made up of standard Motorola and G.E. tone groups, provides 1000 calls. Non-standard tones as well as an optional 19 inch rack mount model are also available.

If you need to send just one call, scout our PE-2P Encoder. The PE-2P is designed to be installed inside the radio or other enclosure, and is programmable from a memory base of 32 tone frequencies. Both the PE-1000 and PE-2P Encoders are perfect matches for our programmable 1000 call SD-1000 Two-tone Sequential Decoder.

The PE-1000 isn't just a legend, it's ready for pronto one day delivery and is covered by our epic one year, no hassle warranty. Why not send that tired old encoder to the Happy Hunting Grounds with the wampum it takes for a few service calls.

PE-1000 Desktop Encoder	$224.95
PE-1000RM Rack Mount	324.95
PE-2P Single Call Encoder	54.95
SD-1000 Decoder	59.95

(all prices are service station net)

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